SITE REPORT FOR:

SEDIMENT TOXICITY IDENTIFICATION EVALUATION DEMONSTRATION:

HUNTER'S POINT SHIPYARD
PARCEL F

SUBMITTED TO:

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING SERVICE CENTER
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EXECUTIVE SUMMARY

A Toxicity Identification Evaluation (TIE) demonstration was conducted using sediment pore waters from the Hunter's Point Shipyard in San Francisco Bay, California. The study was part of a demonstration project for Naval Facilities (NAVFAC) (technically managed by U.S. Navy Engineering Field Activity Northeast (EFANE)) designed to illustrate the applicability of TIEs in resolving the sources of toxicity and hence assist with management of contaminated sediments. The TIE was conducted with the same sediments that were characterized as part of an ongoing Validation Study supported by the Installation Restoration support team at EFD Southwest (SWDIV). Results of the TIE test exposures confirmed previous findings that ammonia is a major source of toxicity in Hunter's Point sediments, but it was also found that an additional source of toxicity attributable to metals is present in selective site samples. However, a similar correlation was also observed at the reference station, indicating that metals-related toxicity might not be site-specific.

Of the five areas within Hunter's Point Shipyard Parcel F sampled for SWDIV during the final two weeks of May, 2001, four were selected for TIE testing. Sediment samples tested in SAIC's TIE study were distributed as follows: two (co-located surface and subsurface samples) from Point Avisadero, one each from the Eastern Wetland and the Oil Reclamation Area, six from the South Basin (including a co-located surface and subsurface collection), and one from the reference site (Paradise Cove). The sample locations were chosen to represent a variety of contaminant types and/or ammonia in toxic concentrations. The samples were also selected to address issues concerning spatial variability.

The TIE consisted of a sequential series of toxicity tests consisting of exposures to serial dilutions of pore waters using the sensitive embryo-larval stages of the purple sea urchin (*Strongylocentrotus purpuratus*) and the Atlantic silverside fish *(Menidia menidia).* Test organisms were exposed to untreated sediment pore waters and then to a series of treated pore waters. The first five treatments were conducted sequentially, while the final two manipulations were independent of each other. Each step was conducted to identify a unique class of contaminants, as follows:

Untreated: Establishes baseline toxicity.
Sodium thiosulfate (STS): Added to reduce oxidants such as chlorine, halogenated amines and several cationic metals including Cd^{2+}, Cu^{2+}, Ag^{1+} and Hg^{2+} (with low reduction of Ni^{2+}, Zn^{2+}, and Pb^{2+}) in pore water samples (U.S. EPA 1991).
Ethylenediamine Tetraacetic Acid (EDTA): Added to chelate divalent cationic metals (i.e., Al^{2+}, Ba^{2+}, Fe^{2+}, Mn^{2+}, Sr^{2+}, Cu^{2+}, Ni^{2+}, Pb^{2+}, Cd^{2+}, Co^{2+} and Zn^{2+}) by replacing dissolved metals with less bioavailable forms.
Filtration: Required to remove excess particulates to improve efficiency of the solid phase extraction treatment.
Oasis® solid phase extraction (SPE): Removes non-polar organic contaminants such as polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs).
Ulva lactuca: Plant that removes ammonia, and potentially other residual sources of toxicity (e.g., non-ionic contaminants, metals)

Following the Oasis® extraction, a pH adjustment was performed to provide additional evidence for the role of confounding factors (e.g., ammonia):
Increase pH: Change the equilibrium of ammonia to favor the more toxic un-ionized form; change the equilibrium of sulfides to favor less toxic forms.

A follow-on TIE test series was conducted using the embryo-larval sand dollar (*Dendraster excentricus)* test (a replacement echinoderm for the original urchin test species, due to seasonal availability). In these tests, an additional, modified sequence was employed, placing *Ulva* additions first to remove the potentially masking effects of ammonia toxicity prior to the assessment of toxicity reduction due to other treatments. The modified design was applied to a three-station subset of the original test stations.

Results from all tests are summarized in Table ES-1, which is accompanied by interpretive text in Section 4 of this report.

General conclusions can be summarized as follows:

- Levels of toxicity observed in the pore water exposures were substantially higher than in bulk sediment and Sediment Water Interface toxicity tests, where minimal toxicity occurred. Known differences between the tolerance limits of the species tested as well as differences in exposure concentrations account for these differences. For the TIE study sediment pore water was used as the test media, thus representing a potential worse-case scenario for exposure. Results of the TIE study should contribute as ancillary data in identifying potential sources of toxicity within the overall weight of evidence process utilized for the Hunters Point Validation Study.

- Toxicity did not differ substantially with depth in the two stations where surface and subsurface sediments were represented.

- Very high oxygen demand in the pore water samples offers clues to the biogeochemical properties governing the bioavailability of the toxicants. Ammonia has a relatively high oxygen demand (consumes oxygen through transformation to nitrite and nitrate), but it is likely that the formation of metal oxides and sulfides, as well as biotic factors (i.e., bacteria) contributed to the oxygen depletion in the samples.

- Toxicity reductions due to STS reduction and EDTA chelation observed in all species were correlated with elevated pore water concentrations of metals, especially aluminum, copper, manganese and zinc. A similar correlation was also observed at the reference station, indicating that metals-related toxicity may not be site-specific.

- Ammonia toxicity was the predominant source of toxicity removed by TIE procedures for urchins, sand dollars and fish, but other contributors to effects were observed, particularly with the purple urchin. Follow-on testing with sand dollars confirmed that factor(s) other than ammonia contributed to toxicity.

1. INTRODUCTION

The Hunter's Point Shipyard in San Francisco Bay, California, a location with tidal salt, potentially contaminant-impacted aquatic habitats, was chosen as the second site to be evaluated as part of the Sediment Toxicity Identification Evaluation (TIE) demonstration project for NAVFAC. The project was developed to evaluate the effectiveness of TIEs conducted with sediment pore waters to resolve ecological risk concerns. The Technical Proposal for the Demonstration Project was submitted and approved in March 2001 (SAIC, 2001a), and a final addendum to the proposal was submitted in May 2001 (SAIC 2001b). The Hunter's Point site conforms to the principal site-selection criteria developed for the demonstration project:

- An identified need exists for information that may clarify the source of apparent toxicity. One objective of the on-going Validation Study (VS) for the site is to determine the chemical characteristics that will guide remedial decisions to treat, depose or investigate reuse options for the contaminated sediments. Thus, results from the TIE should help to resolve regulatory uncertainties and assist site management decisions.

- The site presents a unique case study relative to environmental and contaminant characteristics at the Indian Head Naval Surface Warfare Center (NSWC), the first site chosen for the demonstration project. Hunter's Point is a saltwater site incorporating numerous habitat types and sources of Contaminants of Potential Concern (CoPCs), while Indian Head is a freshwater riverine site with more defined sources of contamination. Thus, the TIE program should demonstrate applicability in diverse habitat conditions, and serve to address uncertainties with regard to the principal toxic agents that may be found across a wide variety of Navy sites.

The Team involved in the TIE demonstration study at Hunters Point includes the primary technical team (SAIC), the Navy Engineering Field Activity Northeast (EFANE) oversight/liaison team, the Installation Restoration support team at Navy Southwest Division (SWDIV IR staff and contractors), and Regulatory Team (Hunter's Point Base Closure Team). The Team is committed to a close collaboration with the TIE effort to assure successful and efficient study designs and sampling efforts.

1.1. BACKGROUND

Navy Southwest Division (SWDIV) Naval Facilities (NAVFAC) Engineering Command is currently performing a Validation Study within Parcel F at the Hunter's Point site. The purpose of the study is to confirm the location and extent of contamination identified as the "Low-Volume Footprint" delineated in the Parcel F Feasibility Study Draft Report (Tetra Tech EM, Inc., and Levine-Fricke-Recon, Inc., 1998). A site description and history, as well as a review of the findings from previous studies, is presented in the Validation Study Work Plan (Battelle *et al.*, 2000a). Fifty-nine surface sediment samples were collected for the Validation Study. Through coordination with SWDIV, extra volumes were collected for eleven of the sediments, including the reference station, to provide split samples for the TIE demonstration.

Accordingly, the TIE demonstration reflects the shared interest of all parties involved to efficiently coordinate a plan that is mutually beneficial.

A recent report summarizing existing sediment chemistry and bioassay data for Parcel F, (Battelle *et al.*, 1999) found exceedences of sediment screening levels for copper, chromium, lead, zinc and polychlorinated biphenyls (PCBs). Nevertheless, toxicity was most strongly correlated to total ammonia. In this and other historical and recent surveys conducted at Hunter's Point, sediment constituents were measured to varying degrees, and considerable uncertainty remained with regard to the potential for toxicity of CoPCs and confounding factors. Only a limited number of samples were fully evaluated to characterize factors that mediate toxicity (e.g., organic carbon and ammonia), and there had been no analyses to determine the relative presence of Acid Volatile Sulfides (AVS) and Simultaneously Extracted Metals (SEM) that affect bioavailability and consequently toxicity in metal contaminated sediments (Hansen *et al.*, 1996). Still, the available data indicate that locations generally characterized by lower Total Organic Carbon (TOC) and or alternatively, high ammonia (NH_4^+), had the greatest potential for toxicity (Battelle *et al.*, 1999; SAIC, 2001a).

1.2. OBJECTIVES

The objectives of this Phase 1 TIE study are to provide data to identify sources and magnitude of toxicity associated with contaminants at the site as well as to characterize the extent to which confounding factors (e.g., ammonia) are potentially involved in the toxic response. The sampling design developed to meet these objectives is presented in Section 2 as well as a review of the technical approaches and methodologies used for field and laboratory analysis. Results and conclusions are presented in Sections 3 and 4, respectively, with references provided in Section 5.

2. TECHNICAL APPROACH

The following Sections discuss the technical approaches used in the selection of TIE stations (Section 2.1), the interpretation of chemistry data (Section 2.2), and the TIE data (Section 2.3). Field and laboratory methodologies (Section 2.4) used in the collection and analysis of toxicity data (Section 2.5) are also presented.

2.1. STATION SELECTION STRATEGY

The choice of sampling locations within the Hunter's Point study area is shown in Figure 2.1-1. Sediment sampling locations chosen from the total of fifty-nine Validation Study stations emphasize sites with CoPCs measured during previous studies that exceed NOAA Effects Range Median (ERM) benchmark concentrations. Stations were chosen to represent the higher concentrations of the range of CoPCs, as well as a broad range of ammonia concentrations. For purposes of the TIE Demonstration, stations were also chosen to cover various source inputs. The stations were selected with regard for each of the following criteria:

- Bulk sediment concentrations exceed benchmarks for potential/probable effects;
- Mediating factors (e.g., TOC, AVS) that may affect chemical bioavailability;
- Confounding factors (e.g., NH_4^+) that directly contribute to toxicity;
- Contaminants other than cationic metal CoPCs (e.g., tributyltin (TBT)) that might contribute to toxicity, based on benchmark Hazard Quotients (HQs); and
- Spatial distribution that reflects unique contaminant sources and different environmental conditions or CoPC distributions that represent gradients in chemical availability.

In order to satisfy the data needs, samples were obtained from eight locations sampled during the Validation Study (Battelle *et al*., 2000a; Figure 2.1-1). Two additional samples were collected from the 5-10 cm stratum as secondary collections following surface sampling (0-5 cm) at the same station. The stations were chosen not only to maximize opportunities to observe and characterize potential toxicity from CoPC and confounding factors, but also to provide a representation of the varying contaminant signatures and sediment characteristics that occur across the Low-Volume Footprint areas. The stations for the TIE were selected from the following areas:

- Point Avisadero (PA); HP-1 and HP-2
- Eastern Wetlands (EW); HP-3
- Oil Reclamation Area (OR); HP-4
- South Basin (SB); HP-5 through HP-10
- Paradise Cove (reference site); HP-REF

In the PA area, stations were chosen to represent the sites where copper, zinc and lead all exceeded ERL values. Stations HP-1 and HP-2 were selected for TIE testing on pore waters from subsurface sediments because of the known elevations in CoPCs, as well as expected differences in sediment characteristics with depth (Battelle *et al.,* 2000a).

One station was selected from both the EW and OR areas in order to represent the potential differences in toxic signatures at the two sites. The EW station represents a single hot spot in the area with four target CoPCs exceeding ERM levels. The OR station is characterized by copper, zinc and lead that were above Effects-Range Low (ERL) values.

In the South Basin Area, six stations on the eastern bank were selected to represent toxic sediment with a mixture of contaminants that exceed ERL values but with consistent Effects Range-Median (ERM) exceedences for zinc. Finally, a subsurface sample (HP-6), co-located with HP-5, was taken because of its proximity to a landfill (Battelle *et al.*, 2000a).

2.2. CHEMICAL EVALUATION

The toxicology of identified chemicals at the Hunter's Point site with respect to the observed toxicity in TIE treatments is a key factor in elucidating the sediment constituents responsible for toxicity. For purposes of the TIE Demonstration, the chemistry data from each of the selected stations were assessed for toxicity potential based on one or more of the following

characteristics: Bulk sediment concentrations that exceed benchmarks for potential/probable effects (Section 2.1.1);

- Divalent metal concentrations (simultaneously extracted metal (SEM)) that enhance potential for divalent metal (Cu, Cd, Pb, Ni, Zn) and silver (Ag) toxicity (Section 2.1.2);
- Pore water benchmark exceedences that reflect location-specific sediment characteristics (e.g., low TOC or low AVS increasing the potential for chemical bioavailability (Section 2.1.3);
- Non-CoPC sources (e.g., NH_4^+) that confound the elucidation of CoPC contributions to toxicity (Section 2.1.4);
- Contaminants other than the identified CoPCs (e.g., pesticides) that could contribute to toxicity (Section 2.1.5); and
- Spatial variation that might reflect novel environmental conditions or CoPC distributions that may represent gradients in chemical availability (Section 2.1.6).

2.2.1. Sediment Benchmark Exceedences.

Results of the bulk sediment analyses were compared to selected sediment benchmarks to reflect the potential for toxicity of the sample. The sediment-based benchmarks used to evaluate the exposure conditions of concern at the Hunter's Point site are from U.S. EPA (1997) and NOAA (1999) and are summarized in Table 2.2-1. Most values are NOAA Effects Range-Median (ERMs) and Aquatic Effects Threshold-High (AET-H) concentrations. When such values were not available, most commonly alternate Aquatic Effects Threshold-Low (AET-L) and Probable Effects Levels (PELs) were used.

It is noted that the above sediment contaminant benchmarks are derived from field measurements of adverse effects expressed in a variety of ways (e.g., toxicity, decreased benthic diversity) and hence frequently reflect the cumulative response to the co-occurrence of multiple contaminants. Often these co-contaminants are at very elevated levels, and most of the data has originated from highly contaminated sites. Accordingly, the resulting chemical-specific benchmarks can be overly conservative. With these uncertainties in mind, it is important to evaluate other measures of potential toxicity, as discussed in the following sections.

2.2.2. Divalent Metals Bioavailability

Simultaneously Extractable Metal:Acid Volatile Sulfide (SEM:AVS) measurements are conducted on sediments to assess the bioavailability and hence toxicity of divalent metals. In this method, the amount of metal liberated form the sample during extraction is measured, and at the same time, the quantity of sulfide released from the sediment is also measured. Sulfides are a common constituent of organic-rich sediments that will bind divalent metals in direct proportion to their respective molar concentrations (Hansen *et al.*, 1996). SEM metals bind to AVS and when concentrations of toxic metals occur in excess of the available AVS concentration (on a molar basis), toxicity can be expected. Hence, for Hunter's Point, SEM:AVS data was used to evaluate the potential for divalent metal toxicity.

The difference approach (SEM-AVS) for quantifying SEM:AVS data was used in the present evaluation as it most accurately represents available SEM concentrations; the more traditional ratio approach (SEM/AVS) commonly used tends to misrepresent available concentrations of SEM at low AVS concentrations. The EPA National Sediment Quality Inventory has adopted the difference approach; an SEM-AVS value of 5 µM/g dry wt is recommended as a screening value for identification of bedded sediments of concern with regard to potential divalent metal effects on aquatic biota (U.S. EPA, 1997).

In planning the Hunter's Point TIE study, estimated as well as measured SEM:AVS data were used to identify locations of potential metal toxicity for the purposes of station selection for the TIE demonstration (SAIC 2001a). Until recently SEM:AVS analyses were not typically included in sediment chemistry measurements, hence the evaluation of historical sediment data for potential divalent metals toxicity is problematic. Here, the concentration of SEM was roughly estimated to be equal to the corresponding bulk sediment concentration due to similarity in the chemical extraction methods for SEM and typical bulk sediment metals analysis (both are weak acid digestion methods). Also, in the absence of AVS data, iron concentration in bulk sediment was used as an indicator of AVS binding capacity. This is because the principal form of AVS is iron monosulfide (FeS), although the more stable pyrite form (FeS_2) might also be present. While this approach was used in the station selection process, direct measurements of SEM:AVS were employed in the TIE investigation.

2.2.3. Pore Water Benchmark Exceedences

Similar to the bulk sediment benchmark comparisons, pore water chemistry data are used for comparison with water quality benchmarks to assess the potential for toxicity of the sample. For chemical contaminants measured in the current study, the appropriate pore water benchmarks are the USEPA Water Quality Criteria - Saltwater Acute (WQC-SA) values (Table 2.2-2), or lacking those, Water Quality Criteria – Freshwater Acute (WQC-FA) values. In the absence of a water-derived benchmark, pore water benchmarks for organics were derived from sediment benchmarks using the Equilibrium Partitioning (EqP) model approach of DiToro *et al.* (1992) as follows:

$$1) \qquad C_p = C_s/(f_{oc} * K_{oc})$$

In the above equation, organic chemical pore water concentrations (C_p, µg/L) are calculated from the corresponding sediment concentration (C_s; µg/kg) based on the fraction of organic carbon (f_{OC}) in the site sediment (f_{oc} = %TOC/100) and the organic carbon/water partitioning coefficient (K_{OC}) for the CoPC. Values for K_{oc} are determined from the relationship developed by the USEPA (Karickhoff *et al.*, 1989):

$$2) \qquad \log_{10}K_{oc} = 0.00028 + 0.983*\log_{10}K_{ow}$$

where K_{ow} = the octanol/water partition coefficient. In this process, it is assumed that the resultant value provides a level of protection equivalent to other water quality based benchmarks. For purposes of completing the benchmark table for organics (Table 2.2-2), the sediment

benchmark values were transformed into water-equivalent benchmarks using the EqP model by assuming a default value of 1% sediment TOC concentration. However, when the sediment-based benchmarks were applied to the site sediment, the benchmark was adjusted based on the measured TOC in each sample. It is noted that these estimated benchmarks tend to be overly conservative, as in many cases they are several orders of magnitude lower than published WQC benchmarks (based on lowest observed effect level) when both are available for comparison.

In the present TIE study, concentrations of chemicals measured directly in pore water (i.e. metals) or predicted using the EqP model described above (i.e. organics), were subsequently divided by the pore water benchmarks to calculate Hazard Quotients (HQs). These HQs were used to assess the potential for pore water chemicals to cause toxicity.

2.2.4. Non-CoPC Toxicity Sources.

In the historical and recent surveys conducted at the Hunter's Point site, ammonia concentrations were positively correlated with toxicity to both the urchin embryos in elutriate preparations and the west coast amphipod, *Eohaustorius estuarius,* in bulk sediment tests (Battelle, 2001). In order to evaluate the relative contributions of ammonia the hazard quotient approach has been applied using both total and un-ionized concentrations. As with pore water contaminants, the U.S. EPA Water Quality Criteria - Saltwater Acute (WQC-SA) values (un-ionized ammonia) have been presented as benchmarks in Table 2.2-2, and corresponding HQs were calculated.

Hydrogen sulfide is another potential contributor to toxicity in pore waters that is often overlooked. In a review focusing on sediment toxicity, Wang and Chapman (1999) provide a comprehensive summary of the available data concerning sulfide toxicity to benthic invertebrates and report 96 hr acute LC_{50} values ranging from 0.02-1.1 mg/L total sulfides. Specific data for the organisms used in the present study were not provided. Hence, these values were qualitatively used to assess potential sulfide toxicity in the present study.

2.2.5. Species-specific benchmark exceedences

Whenever possible, it is desirable to use species-specific benchmarks to derive chemistry HQs that are directly applicable to the species used in a TIE test. For many CoPCs and ammonia, these values are often available in the literature. Table 2.2-3 summarizes species-specific acute effect data, as available, for the three species used in the current TIE study. Data for embryo-larval tests with bivalves are provided for some CoPCs as potential surrogates for the purple urchin or the sand dollar when no data for these species were available.

2.2.6. Spatial Heterogeneity in Sample Toxicity.

Characterizations of existing data for the Validation Study areas have demonstrated a range of contaminant loads, with variability between and within areas (Battelle *et al.*, 1999; Battelle, 2001). Some sources of contamination may be shared between areas while others represent more spatially limited area and/or 'hot spot' concerns, based on sediment benchmark HQs. Ammonia was also variable across sites and areas, with the highest concentrations in the

South Basin. The distribution of contaminants with depth is also addressed though the inclusion of subsurface sampling (5 cm – 10 cm) at two stations, in addition to the surface sediments (0 cm – 5 cm) that were collected for all TIE stations. Generally, the TIE stations represented locations with the greatest potential for toxicity but within this group, factors governing toxicity (e.g., low percentage TOC and fines in the Eastern Wetland, moderate levels of both in the Point Avisadero area, and higher levels of both in the south basin) were evaluated.

2.3. TIE TECHNICAL APPROACH

In a TIE investigation, the physical/chemical properties of sediment pore water samples are manipulated in order to alter or render biologically unavailable generic classes of chemicals (U.S. EPA, 1991). Toxicity tests with aquatic organisms provide responses to each type of manipulation and thus reflect the nature of the sources of toxicity within each sample. Depending upon the responses, the toxic contaminants can be tentatively categorized as having chemical characteristics of non-polar organics, cationic metals or confounding factors such as ammonia (U.S. EPA, 1996).

The basis for conducting the specific TIE steps in the present study was developed by U.S. EPA (1996) where specific methodologies and QA/QC are described. SAIC has modified the order of the EPA approach by performing sequential testing of fractions. This permits documentation of cumulative toxicity removal up to and including the production of completely non-toxic samples (Figure 2.3-1). This approach is preferred because absence of residual toxicity provides a clearer demonstration that all the relevant chemical exposures in a sample can be adequately accounted for. At Naval Submarine Base New London, CT, for example, prior remedial investigation and risk assessment studies for Goss Cove suggested actionable risk although considerable uncertainty previously existed as to the contaminants responsible for risk (Navy RPM News 1999; SAIC 1999). The application of the improved TIE process revealed that ammonia (a ubiquitous non-CoPC sediment constituent) and not the suspected sediment contaminants (e.g., PAHs, metals) was responsible for the toxicity.

The first test species selected for the Hunters Point TIE demonstration was the purple urchin (*Strongylocentrotus purpuratus*), chosen through coordination with toxicity testing conducted by Battelle under the Validation Study. Urchins were obtained from the same source (Steven LePage, MREP) for both studies. The second test organism, the Atlantic silverside (*Menidia menidia*) in the embryo/larval stages, was chosen to represent a fish species with sensitivity to a variety of contaminants. A third, limited series of tests were conducted with the sand dollar, *Dendraster excentricus,* to further resolve the role of CoPCs vs. confounding factors in pore water toxicity.

TIE Manipulations. The Phase I TIE characterization consists of the following characterization steps or tiers: (1) Baseline Toxicity Test, (2) Sodium thiosulfate (STS), (3) Ethylenediamine tetra-acetic acid (EDTA), (4) Filtered Sample Toxicity, (5) Oasis® solid phase extraction (SPE) column, and (6) *Ulva lactuca* incubation The original work plan called for a zeolite treatment to remove ammonia, but preliminary tests conducted by SAIC with a commercial zeolite that had been successfully applied in freshwater tests resulted in poor seawater control responses. Recent

work with *Ulva* for TIE purposes (Ho et al.;1999 and Lapoda and Grovhoug (2001) confirm that this treatment may result in uptake of CoPCs. Hence, as with zeolite, the *Ulva* treatment placement at the end of the TIE treatment is the only way to clearly segregate the effects of ammonia removal. Supplemental tests were conducted with sand dollars, with *Ulva* treatments conducted both first and last. One purpose of these tests was to test for masking effects that can occur when ammonia concentrations are sufficient to result in complete mortality in all treatments, notwithstanding the removal of toxic CoPCs. With the *Ulva*-first treatment, reduction in toxicity resulting from subsequent TIE treatments may underestimate CoPC effects to some degree, but the effects are not masked by ammonia. Each of the pore waters were manipulated according to the sequential extraction scheme shown in Figure 2.3-1. A high pH treatment followed the Oasis® column extraction, independent but in parallel with the *Ulva* treatment. This sequential scheme for pore water manipulations is a revision of the SAIC TIE sequence used in previous studies. Because filtration may remove metals and organics, the placement of the filtration step after the treatments for metals (STS and EDTA) reduces ambiguity of interpretations associated with filtration effects. Filtration has not been found to affect the concentrations of confounding factors.

Guidelines for TIE data interpretation are presented in U.S. EPA (1991) and are summarized below:

1. **Untreated pore water toxicity**. Baseline toxicity tests are conducted to assess toxicity prior to TIE treatment. If no toxicity is observed, TIE manipulations are not performed.

2. **STS**: STS ($Na_2S_2O_3$) is used to reduce oxidants such as chlorine, ozone, chlorine dioxide, mono and dichloramines, bromine, iodine, manganous ions, and some electrophilic organic chemicals and to remove cationic metals including Cd^{2+}, Cu^{2+}, Ag^{1+} and Hg^{2+} (with low reduction of Ni^{2+}, Zn^{2+} and Pb^{2+}) in pore water samples (U.S. EPA 1991). Reduced toxicity indicates oxidants or cationic metals as contributors to overall toxicity of the sample.

3. **EDTA chelation**: Samples are treated with EDTA to chelate divalent cationic metals (i.e., Al^{2+}, Ba^{2+}, Fe^{2+}, Mn^{2+}, Sr^{2+}, Cu^{2+}, Ni^{2+}, Pb^{2+}, Cd^{2+}, Co^{2+}, and Zn^{2+}) (Schubauer-Berigan *et al*., 1993a; U.S. EPA, 1991) and render them biologically unavailable for uptake into cell tissues. Reduction in toxicity of the sample after EDTA treatment indicates the above metals are present in toxic concentrations. A fully or partially toxic response indicates that something other than divalent cationic metallic compounds is a contributor to sediment toxicity.

4. **Filtration**: The pore water is filtered with 0.45 μm filter paper to remove particulates. Toxicity tests conducted on the post-filtered fraction indicate potential toxicity associated with large colloids or particulates in the pore water.

5. **Oasis® SPE**: Pore water samples are eluted through an SPE column (Waters, Oasis® short-body type cartridge) to remove polar and non-polar organic compounds (Waters, 2001). According to Waters' procedures, the pore water is eluted through the column at a

rate of 10 ml/min. For each pore water sample, the column is exchanged after 500 ml is eluted. A reduction in toxicity response to the extraction treatment indicates the potential role of organic compounds as a contributor to the toxicity of pore waters.

6. ***Ulva* treatment**: The green seaweed (*Ulva lactuca*) is generally collected on the day prior to test treatments and held in aerated seawater at 15°C. *Ulva* is added to each of the pore water samples (1g/15 ml) and incubated for 5 hours at 15°C (Ho *et al.*, 1997). A reduction in toxicity response following the *Ulva* treatment indicates ammonia as a source of toxicity.

7. **Graduated pH**: Sample pH is manipulated to discriminate between ammonia and hydrogen sulfide as a source for the observed toxicity (Schubauer-Berigan *et al.*, 1993a; Schubauer-Berigan *et al.*, 1993b; U.S. EPA, 1991). If sample toxicity increases with increased pH (8.8 to 9.1), ammonia is suspected. Conversely, if sample toxicity increases with decreased sample pH (7.2 to 7.8), hydrogen sulfide is suspected.

    A. **Low pH**. Not used in this study because pre-test pore water pHs generally ranged from 7.2-7.6 and further reduction could compromise the tolerance levels of the test organism.

    B. **High pH**. The high pH treatment is produced by adding 1N sodium hydroxide to 100% pore water. The dilution samples generally decrease in pH with increasing dilution (generally 0.1-0.2 per dilution) due to the water dilution.

Spiked samples. In addition to the pore water samples from the site, a "spiked" sample consisting of a clean seawater sample amended with fluoranthene and copper at a concentration sufficient to be toxic was prepared and subjected to the TIE treatments. This sample serves as a positive control for assessment of the capacity of the TIE treatments to selectively remove toxicity and is treated in the same manner as the pore water samples. Details about the spiked sample as well as the field sampling, chemical analyses and toxicity testing procedures are provided in Section 2.3, below.

***Reverse-phase Tests*.** A follow-on TIE test series was conducted using the embryo-larval-larval sand dollar test (*Dendraster* was a replacement echinoderm for the original urchin test species, due to seasonal availability). In these tests an additional, modified sequence was employed, placing *Ulva* additions first to remove the potentially masking effects of ammonia toxicity prior to the assessment of toxicity reduction due to other treatments. The modified design was applied to a three-station subset of the original test stations.

Screening Tests. Prior to TIE testing, pore water screening tests were conducted on samples from the ten stations chosen for the TIE. Screening tests were conducted using the same urchin embryo-larval development test (U.S. EPA, 1995) planned for the full TIE. The urchin larval development test was performed on 100%, untreated pore water, with three replicates per sample. The intent of the screening tests is to eliminates the potential to conduct a full TIE on pore waters that are unexpectedly non-toxic; it also provides the opportunity to limit

the dilution series in cases where more dilute samples would be non-toxic. If the screening test resulted in ≥ 50% reduction in normal development relative to the control response, a four dilution series (10%, 25%, 50% and 100%) TIE would be conducted. If less than a 50% effect was observed, only the 50% and 100% pore water samples would be tested in the TIE manipulation series. Water for control exposures and dilution water was clean saltwater, filtered to 10 µm, in all TIE tests. Reference treatments for TIE tests consisted of pore water extracted from the Paradise Cove reference sediment.

2.4. FIELD SAMPLING, CHEMICAL ANALYSIS AND TOXICITY TESTING PROCEDURES

The Hunter's Point TIE Demonstration was an integrated effort involving sediment sampling, bulk toxicity testing, pore water TIE testing and chemical analyses of sediment and pore water. The following sections provide an overview of these tasks; statistical methods to facilitate interpretation of the data are discussed in Section 2.4. Complete details are provided in the Project Work Plan (Appendix C).

2.4.1. Field Sampling and Pore Water Extraction.

As introduced in Section 2.1, field sampling to collect sediment samples was conducted in conjunction with the SWDIV-NAVFAC Hunter's Point 'Low Volume Footprint' Validation Study (Battelle *et al.*, 2000a). Battelle collected the samples and prepared the splits of the homogenized bulk sediments during the second to fourth weeks of May 2001. TIE samples were shipped from Battelle to the toxicity-testing laboratory (Aquatec Biological Sciences, Williston, VT) on May 30th 2001 and arrived the following day.

For toxicity screening tests (as described in Section 2.3), 60 ml of pore water was extracted from homogenized sediments using the syringe extraction method (Winger and Lassier, 1991). Personnel re-homogenized the sediments and inserted a 50 ml syringe to extract pore water from each sediment bucket. Individual syringes were filled full in as little as 2 hrs or as long as 10 hours generally depending on the sediment grain size. This method served as an efficient means to collect the small volume required for the screening test. Subsequently, pore waters for TIE testing were extracted on June 4th - 5th by centrifuging the samples at 7500 rpm for 15 minutes. A total of 1800-2000 ml were collected from each sediment sample to provide sufficient water for the TIE and analytical measurements. The resulting pore water samples were shipped to SAIC for TIE manipulation.

Various pore water extraction methods are known to produce differing results in TIE studies, with syringe extraction generally resulting in lower levels of toxicity than high speed centrifugation (U.S. EPA, 1991). In a recent workshop convened to assess the state of the science of pore water testing, several advantages of centrifugation for laboratory extractions were noted, including low potential for changes in chemical equilibrium (for both metals and organics), and efficient extraction of both hydrophilic and hydrophobic compounds. Principal disadvantages cited would have toxicity-reducing effects, included sample oxidation, and cell lysis that could contribute DOC(Adams et al, 2001). Also, centrifugation is ineffective in sandy sediments.

2.4.2. Toxicity Testing Methods.

Sediment/Interface toxicity characterization. Sediment toxicity tests (10-day bulk sediment survival of adult amphipods) and Sediment Water Interface (SWI) tests (with larval stages of purple urchins, *Stronglyocentrotus purpuratus*) were conducted by Battelle as part of the Validation Study (Battelle *et al.*, 2000a). These data were used to augment findings from the screening and TIE tests discussed below. Findings from the TIE contribute another line of evidence regarding aquatic risks at the site, and will be evaluated in the context of the various aspects of environmental relevance associated with each set of test results.

Test organisms. Phase I TIE methods (U.S. EPA, 1996) are designed for acutely toxic samples and are based on the use of larval test organisms; all exposures were conducted in 20 ml Fisher Brand HDPE vials in a volume of 10 ml. Larval urchins and sand dollars were obtained from MREP in San Diego, CA (who also supplied organisms used for the Validation Study toxicity test). Fish embryos were obtained by SAIC using in-field techniques to strip gametes and fertilize eggs (U.S. EPA, 1987). The fish were collected from Bissel Cove in North Kingstown, RI, using a seine net. Collection temperatures were 17 ± 2°C, and collections occurred on three separate days. Embryos were cultured in filtered seawater with aeration at temperatures between 18 and 24 °C with temperature conditions varied by batch to insure that hatching occurred either immediately prior to test initiation, or during the anticipated 48-hour exposure period.

Experimental Design. Test procedures generally followed the reduced-volume methodology developed by the EPA for TIEs (U. S. EPA, 1996) and are outlined in Table 2.4-1. Dilutions of the pore water were prepared to generate a series of test concentrations: 10%, 25%, 50% and 100% for the purple urchin test; 50% and 100% for the fish test; and 1%, 10%, 50% and 100% for the sand dollar test. One control treatment was run in parallel with each TIE manipulation. The above experimental design resulted in a total of 264 (11 samples x 4 dilutions x 6 treatments) toxicity tests with the purple urchin, 154 tests (11 samples x 2 dilutions x 7 treatments) with the fish and 160 tests (4 samples x 4 dilutions x 10 treatments) with the sand dollar, plus controls for each treatment and species. Each test was performed in triplicate, and included an additional water-only chamber to monitor water quality.

Spike sample testing. A positive control "spiked" sample was prepared by chemically amending a dilution water sample to produce a measured copper concentration in the untreated sample of 315 µg/L and a nominal fluoranthene concentration of 200 µg/L. The copper was expected to be toxic to the urchin in all dilutions based on the reported EC_{50} value of 24 µg/L for the larval development test (Bay *et al.*, 1993). Toxicity to the fish was expected in the 50% and 100% spiked samples, based on the LC_{50} value (136 µg/L) reported in EPA Aquatic Life Criteria Document for Copper (U.S. EPA, 1985a). Fluoranthene was not expected to be toxic to either species, but was added to the test matrix to track the effectiveness of TIE treatments for copper in the presence of a common organic contaminant.

Water quality. Water quality measurements (temperature, dissolved oxygen and pH) were recorded for each sample prior to distribution into the dilution series. Temperature was

monitored daily in all treatments. Upon test termination, pH and dissolved oxygen were measured in one animal exposure replicate and in a separate water quality replicate.

2.4.3. Analytical Chemistry Methods.

Sub-sampling for Chemical Analyses. As an integral part of the Validation Study, the sediments were also analyzed for priority contaminants, including all CoPCs. The resulting data, as well as other measurements that are critical in the evaluation of sediment characteristics associated with toxicity, including total organic carbon (TOC), grain size and percent moisture, were provided to SAIC by Battelle (Battelle, 2001).

In addition to the Validation Study sediment analyses, laboratory analyses of pore water metals and sediment SEM and AVS were conducted on the eleven TIE samples. On 5 June 2001 re-homogenized sediment were sub-sampled into clean glass bottles for chemical and physical analyses and airfreighted on ice for overnight delivery to the subcontract laboratory (Severn-Trent Services, Baltimore, MD). At the same time, sub-sample of each of the pore waters selected for TIE testing were preserved with 10% nitric acid in clean polyethylene containers and shipped for metals analyses.

Laboratory analyses of SEM:AVS as well as metals in pore water were conducted according to methods outlined in the NOAA Status and Trends Program (NOAA, 1998). These multi-elemental techniques provide sensitive results with a high degree of accuracy and precision (NOAA, 1998). Details regarding sample measurements and QA/QC are provided in the report to SAIC from its contractor, Severn/Trent Laboratories.

Individual analytes are listed with Method Detection Limits (MDL) in Table 2.4-2. MDLs were established for each analyte before analyses were conducted. Laboratory analysis of metals and organic contaminants in bulk sediments were conducted as part of the Validation Study (Battelle *et al.*, 2000a). Sediment evaluations also included TOC and grain size distributions for each sample. Battelle provided SAIC with results from sediment and initial pore water analyses (salinity, pH, ammonia and sulfides), including QA/QC erratum for all analyses (Battelle *et al.*, 2001).

2.5. ANALYSIS OF TOXICITY DATA

In the present study, the interpretation of the toxicity data relied upon three lines of evidence (in decreasing order of importance: 1) results of individual dilutions (10%, 25%, 50% and 100% pore water concentration) compared among treatments, 2) reductions in toxicity relative to performance controls, and 3) cumulative toxicity reductions in the treatment compared to previous treatments. Also calculated was the concentration of pore water required to cause 20% and 50% adverse effects in exposed animals (LC_{20} and LC_{50}) in the fish and effects concentration (EC_{20} and EC_{50}) in the urchin and sand dollar. These values were calculated by linear interpolation of the survival results from each of the TIE treatments (4 dilutions x 3 replicates). ToxCalc software (version 4.0.8, Tide Pool Scientific Software, 2000) was used to generate test statistics including a test for normality of the distribution of the data (Shapiro-Wilkes test) and

confidence intervals by the bootstrapping technique. These results also contained statistical comparisons of each dilution with the performance control (evaluated by ANOVA followed by Dunnett's test to detect statistical differences from controls, alpha = 0.05).

It should be noted that in the qualitative evaluation of the toxicity data, the potential for observing residual toxicity (i.e., sources of toxicity that are not explained by any of the TIE treatments) is greatest at the highest dilutions. Here, exposure concentrations are most likely to exceed removal capacity of the treatment for the particular chemical (Hockett and Mount, 1996). The relevance of the undiluted exposures must also be considered in light of actual exposure concentrations in the field, in that neither the sea urchin embryos nor the fish larvae are likely exposed to full strength pore water for extended durations.

3. RESULTS

3.1. CHEMICAL CHARACTERIZATION OF SEDIMENTS AND PORE WATERS

As discussed in Section 2.1, HQs were calculated by normalizing sediment and pore water concentrations of chemicals to appropriate benchmarks. Results from laboratory analyses of sediments (Appendix A-1-1, A-1-2) and pore water metals (Appendix A-1-3) as well as predicted pore water concentrations for organics (Appendix A-1-4) have been converted into HQs (Appendices A-2-1 and A-2-2, respectively) through normalization to the respective sediment and pore water benchmarks as discussed in Section 2.1. A brief summary of the HQ results is presented here; a more detailed discussion is incorporated into the toxicity results addressed in Sections 3.2 and 3.3.

Interpretive summaries for sediment and pore water HQs can be found in Table 3.1-1 and Table 3.1-2, respectively. Results were categorized in a manner deemed useful for prediction of acute toxicity responses in the TIE treatments: A concentration above the acute threshold (HQ>1) suggests a possible toxicity ("+"), while elevations that are three-fold and ten-fold above the benchmark indicate likely ("++") and probable ("+++") toxicity, respectively.

The sediment HQ calculations show that all ten of the TIE stations and the reference station had at least two analytes above sediment benchmarks (Table 3.1-1) and that up to seven benchmark exceedences were observed, albeit at only one station (HP-8). Analytes showing the most common exceedences were cobalt, manganese and nickel, which exceeded benchmarks at all stations (including the reference station), and Total PCBs, exceeding benchmarks at seven stations. Less frequent exceedences were observed for mercury (five stations), copper (four stations) and chromium (one station). Of the metals, only nickel was present in concentrations greater than three times the benchmark, and at only two stations (HP-4 and HP-8). Values for SEM-AVS were negative except in samples HP-1, HP-8 and HP-REF, where SEM exceeded AVS by 1.2, 1.3 and 0.4 μmole g^{-1} respectively. For Total PCB exceedences, all but one were three-fold above unity. Two pesticide exceedences were observed (4, 4'-DDD, HP- 8 and dieldrin, HP-6); no PAH exceedences were observed.

The HQs derived from pore water concentrations indicated that manganese exhibited elevations above the acute benchmark at all stations including the reference station (Table 3.1-2). The highest manganese exceedence, greater than ten-fold above the benchmark, was observed at the reference station. Copper also frequently exceeded the benchmark (at nine stations and the reference station), with the highest exceedence (greater that ten-fold unity) observed at HP-7. Other notable exceedences were for aluminum (three stations and the reference station) and arsenic (one station), while a minor zinc exceedence was observed at HP-7. Neither PAHs nor PCBs exceeded benchmark based on pore water estimates made from sediment concentrations using the equilibrium-partitioning model.

The HQs derived for un-ionized ammonia exceeded unity for every station other than HP-6 (Table 3.1-2). Station HP-3 had a concentration that exceeded the benchmark by greater than a factor of ten. Most other stations (HP-4, HP-5, HP-8, HP-9 and HP-10) exceeded the benchmark by greater than three-fold. The remaining stations (HP-1, HP-2 and HP-7) exceeded the benchmark to lesser degrees.

A species-specific HQ table (Table 3.1-3) was prepared to represent pore water risks to the test species. For urchins, copper HQs were above reference (HQ=1.5) at Stations HP-7 (HQ=16), HP-8 (HQ=5.8) and HP-10 (HQ=2.2). The urchin benchmark for zinc was also higher than reference (HQ=1.4) at Stations HP-2 (HQ=2.1), HP-7 (HQ=11), HP-8 (HQ=7.8) and HP-10 (HQ=2.4). Finally, the urchin benchmark for aluminum was exceeded at all stations but was above reference (HQ=8.5) only at Stations HP-7 (HQ=61) and HP-8 (HQ=23). Other than the exceptions noted above, the HQs for copper, zinc and aluminum across the HP stations were low (0.7 to 2.4) and below reference.

The species-specific pore water HQs for larval fish and sand dollar were lower than those observed for the urchin. For copper, only one station approached concentrations representing potential acute toxicity to fish (HP-7; HQ=0.95). Manganese HQs for fish at the HP stations included five values ranging from 1.0 to 2.3 (Stations HP-4, HP-1, HP-5, HP-9 and HP-8, in order of increasing HQs). The reference station was also elevated (HQ=3.9). Finally for the sand dollar, two stations (HP-7 and HP-8) were above acute toxicity thresholds for copper, with HQs of 6.5 and 2.3, respectively.

For ammonia, the species-specific HQs were much higher for the urchin than for the fish owing to the greater sensitivity of urchins to ammonia. Because the measured ammonia concentrations represent pore water used to test both species, the fish follow the same relative potency pattern as the urchin. Un-ionized ammonia HQs for the urchin (derived from un-ionized ammonia concentrations calculated from Total Ammonia; Appendix A-3), were greater than ten for six stations (HP-5, HP-8, HP-4, HP-9, HP-10 and HP-3, in order of increasing values). Three of the remaining stations (HP-1, HP-2 and HP-7) had HQs between 3 and 10 while Station HP-6 had an HQ of 1.1, below the reference station value (HQ=2.1). For the fish, un-ionized ammonia HQs were in the acute effects range (i.e. HQ>1) at Stations HP-3, HP-9 and HP-10, and an order of magnitude above reference (HQ=0.1).

3.2. TOXICITY RESULTS IN SEDIMENT AND WATER MATRICES

Results of bulk sediment survival with the amphipod were evaluated in conjunction with chemistry results discussed above to select the pore waters to be used for the TIE investigation. Survival of the amphipod in bulk sediment samples ranged from 72% to 102%, when normalized to the control survival of 97% (Table 3.2-1). Survival in both sediments from Point Avisadero (HP-1 and HP-2, surface and subsurface samples, respectively) was 75%. Survival results in the Eastern Wetland sediment (HP-3) and in the Oil Reclamation Area (HP-4) were both equivalent to control responses. Generally, toxicity was not observed in the South Basin sediments, but survival in two of the six representative sediments (HP-6, a subsurface sample) and HP-9) were 72% and 76%, respectively. Results from the current bulk sediment test are consistent with those reported in the Parcel F Data Summary report (Battelle *et al.*, 1999). Grain size analyses results compiled into three size fractions, gravel, sand and fines (silt + clay), are presented in Appendix A-4. The majority of the stations contain greater than 50% fines except for several stations (HP-3, 7, 8 and 10) that contain a considerable (>70%) sand component. Moisture content of the samples was fairly consistent, ranging from 25-57%. These parameters are within acceptable ranges to the amphipod.

For the present round of amphipod bulk sediment tests, the pore water ammonia concentrations are similar to ammonia measured in pore waters collected for the TIE study (Table 3.2-2). Values were variable, ranging from 4.4 mg/L to 34.9 mg/L, and did not correlate well with the marginal toxicity observed. In this range of concentrations, ammonia toxicity is not expected, as amphipods are reported to tolerate total ammonia concentrations < 60 mg/L (U.S. EPA, 1994). The TOC concentrations in the sediment and in pore water samples are also presented in Table 3.2-2. Concentrations were generally low, ranging from 0.34 to 1.7% across all sediment samples used for the TIE.

Table 3.2-1 presents a summary of toxicity observed in pore water TIE tests with the urchin and fish relative to the toxicity test results from bulk sediment tests with the amphipod. The effects observed in the SWI tests with urchins are also presented. The total absence of normal development in the urchin exposed to 100% pore water contrasts dramatically with the minimal effects on survival of the amphipod in bulk sediment exposures. Almost as dramatic and more difficult to explain are the differences between the rate of normal development of the urchin in 10% pore water compared with development of the same species in SWI exposures, where the dilution was only 1:5 rather than 1:10. Survival of the fish in exposures to 100% pore water in the TIE test represent yet another unique pattern of toxicity across the set of ten stations. While differences in results from bulk sediment, elutriate and pore water tests are common in sediment toxicity assessments, the degree of differences observed here is unusual, and provides opportunities to discern the qualities of the samples that resulted in this broad range of response. Principal attributes of the bulk sediment test, one or more of which would account for the relatively low adverse response rate, include: 1) a mode of exposure characterized by limited uptake of pore water; 2) retention of contaminants by particulates and chemical complexes with lower availability in interstitial pore water than in extracted pore water, and 3) lower sensitivity of the amphipod relative to the urchin and fish. The latter is the most probable explanation when ammonia toxicity is likely.

In the SWI test, the urchin exhibited minimal adverse effects relative to the same species in pore water exposures. A partial explanation for this could be that while the SWI test preparation has a dilution component similar to the lowest dilution in the pore water test (5 vs. 10), potential contributors to toxicity, including ammonia and contaminants were only made bioavailable by the process of centrifugation. Another procedural factor that was unique to the pore water collection and handling was the need to oxygenate most of the samples prior to test initiation. Several of the pore waters had very high oxygen demand, with dissolved oxygen measurements falling to concentrations as low as 0.2 mg/L in samples prepared for TIE testing. An oxygenation process was required to provide the best potential to meet acceptable water quality conditions for the toxicity tests, and associated changes in potential sources of toxicity resulting from this pre-TIE manipulation are possible. However, this seems an unlikely cause for increased toxicity because metal toxicity is usually ameliorated by oxidation reactions (O'Day *et al.*, 2000). Also, the different responses of the fish and urchins exposed to pore waters are consistent with differences in tolerance of the two species (Table 2.2-3).

One of the simplest effects of oxygenation is elevation in pH corresponding to the displacement of CO_2. While all sample pHs increased over the course of the TIE test exposures, the oxygenated samples tended to increase 0.2-0.4 pH units more than non-oxygenated treatments (e.g., 7.4 to 8.4 vs. 7.4 to 8.2). Thus oxygenation through pH changes could potentially have facilitated the oxidation of ammonia to free atmospheric nitrogen but it is more likely that the process, resulted in some shift in the relative concentrations of ammonia, nitrite and nitrate, which are also toxic to varying degrees. Also, the pH shift increased the proportion of the more toxic un-ionized ammonia form. Oxidation of Fe^{+2}, Mn^{+2}, hydrogen sulfide and dissolved organic carbon (DOC) as well as the elimination or oxidation of volatiles are also potential outcomes resulting from oxidation (Adams et al., 2001), and especially from oxygenation .

3.3. TIE RESULTS

The interpretation of TIE toxicity responses is based on both the observed magnitude of the toxicity in the treated sample and the relative change in toxicity from the previous samples in the TIE sequence. It is also useful to evaluate changes as they occur across the sample dilutions. Some toxicants may only exhibit effects in less dilute samples while others may be evident across multiple dilutions. Changes in toxicity of a potent toxicant may only be seen in dilute samples, when additional toxic constituents mask the removal of a single class of toxicants. The individual dilutions responses are presented with highlighting to illustrate changes in toxicity with each TIE treatment (Tables 3.3-1 to 3.3-3; laboratory report presented in Appendix B-1). Responses that are statistically different from performance control responses are presented in boldface. In addition, the relative magnitudes of changes associated with each TIE manipulation for each sample are synthesized in Tables 3.3-4 to 3.3-6. Supporting lines of evidence are obtained with assistance from plots of mean survival responses versus pore water concentration (Appendix B-3), and also from calculation of statistical endpoints that estimate dilutions (pore water percentage) that would result in specific levels of mortality ('LC' values; Appendix B-4 to

B-6; interpretive summary presented in Appendix B-7 to B-9), including corresponding 95% confidence limits for each treatment calculated with Toxcalc software (Appendix B-2).

In the sections below, results of QA/QC procedures are presented first to assess the efficiency of the treatment procedures (Section 3.3.1). Next, an interpretive summary of the TIE responses is presented to provide the reader with an overview of the study findings (Section 3.3.2), as well as a discussion of the patterns of response that may vary spatially across the study area. Section 4 presents a synthesis of treatment responses evaluated in conjunction with the associated chemistry, whereby specific chemicals or confounding factors are attributed as likely toxicity sources. Uncertainty generated through the data synthesis process is also reviewed.

3.3.1. Quality Assurance Results for TIE Tests

Completeness. The urchin screening test exposures were conducted as described in the Work Plan (Appendix C). For the TIE tests with the urchin, the low pH treatment was excluded from the final test design because pore water pHs in the range of 7.2-7.6 approached acceptable limits for testing, and further reductions were not warranted. The fish were available in limited supply and for this reason, only the 100% and 50% dilutions were tested. In addition, because partial hatching occurred prior to test initiation, embryos were generally distributed to the 50% dilutions and newly hatched larvae were used in the 100% pore waters. In some of the 50% dilutions there were only sufficient animals for two replicates rather than three. Because no effects were observed in the fish exposed to 50% dilutions, the shortage of animals did not compromise interpretation of results. There was a shortage of pore water from HP-7, resulting in the omission of the filtrated pore water test with the urchin, and all of the 100% samples for the fish. The shortage was due to a centrifuge explosion that occurred during the pore water extraction of HP-7 sediment.

Performance standards. In the screening test conducted with urchins, all test criteria were met and performance controls were highly successful, with a mean of 92% normal development. The reference toxicant test with copper also performed within control standards. In the TIE tests, normal development in each of the control treatments was sub-optimal, ranging from 59 to 78% normal development. This was attributed to the additional sensitivity of the test organisms, which were collected very late in the spawning season (only a few out of several dozen animals could be spawned). The high pH treatment was omitted from analyses because the performance control response (53% normal development) was lower than the performance control results for the other treatments, and because pHs at the end of the exposure were not different from the treatments without pH adjustment. Given the normally strong buffering capacity of seawater, the large number of test chambers (~ 1000, in this case), and small volumes it was difficult to maintain constant pH exposure conditions. In the tests with the sand dollar, control treatments produced high rates of normal development, ranging from 90% to 96% in all treatments with the exception of the *Ulva*-last treatment where normal development was anomalously low (60%). The reference toxicant test conducted with sand dollars exposed to copper performed within control standards.

Most of the pore waters received for TIE exposures also had very low DO values (<1 mg/L), with the exception of HP-1. Stations HP-2 and HP-4 and the reference site (HP-REF) were also marginally hypoxic (3-5 mg/L); the control and spiked samples and HP-1 were not hypoxic. All hypoxic samples were bubbled with pure, medical grade oxygen, to reach an initial concentration of > 20 mg/L. This step was required in order to provide sufficient DO to prevent mortality in the fish (LC_{50}= 2.5 mg/L; U.S. EPA, 2000). Even with oxygenation, HP-3, HP-8 and HP-10 still had DO < 1.0 mg/L on Day 1 and complete mortality of fish larvae occurred in the untreated pore waters of these samples. Because DO less than 1.0 mg/L is known to be lethal to larval fish (U.S. EPA, 2000), the TIE tests with this species were not considered useful in assessing other potential sources of toxicity. However, all three of these samples did have complete survival following the *Ulva* treatment, where DO levels were acceptable. In this case, the *Ulva* not only removed sufficient ammonia to allow survival, but photosynthesis also provided supplemental oxygen to restore D.O. to acceptable levels for the larval fish. For urchin exposures, low DO concentrations (< 1.0 mg/L), were occasionally observed (Appendix B-10), but not to an extent that TIE responses should be masked by DO effects. Embryo-larval tests with bivalves have indicated that DO concentrations between 0.5 mg/L and 1.0 mg/L are not lethal in exposures up to 24 hrs (Morrison, 1971; Huntington and Miller, 1989). It appears that sea urchins and sand dollars in this stage may have similar or greater tolerance.

Finally, spurious pHs were recorded in the performance control (PC) water, (seawater collected from Narragansett Bay at the U.S. EPA Laboratory during the week of the TIE, filtered with 1µm glass fiber filters) and in the spiked sample generated using control water. Low pHs (6.9, 6.8) occurred in the EDTA treatment PC and spike while high pHs (9.2, 9.3) resulted from *Ulva*-treated PC and Spike samples. This indicates an abnormal ionic matrix with low buffering capacity in the control water. This effect was not observed in any other samples, or in any other TIE treatments involving control water.

Spiked sample results. A spiked sample containing 315 µg/L (measured) copper, 200 µg/L (nominal) fluoranthene, and 25 mg/L (measured) ammonia was used in TIE toxicity tests with urchins and fish in order to demonstrate the effectiveness of the TIE manipulations. For the urchin, the initial untreated, undiluted sample was toxic to 100% of exposed organisms at all dilution levels (Table 3.3-1). Following all TIE treatments, approximately 79% of the originally observed toxicity was removed. Of this, STS contributed little to toxicity reduction, but the EDTA treatment removed 46% and *Ulva* removed the remainder. It is most common for STS to remove copper toxicity, but higher removal capacity with EDTA has also been reported (Hockett and Mount, 1996; Schubauer-Berrigan *et al.*, 1993a). TIE treatments should not be expected to totally remove toxicity in all case, particularly when the spike represents a very high level of toxicity (e.g., the copper species-specific HQ was 39; 6.7 times the highest level measured in TIE pore water samples). The efficiency of toxicity reduction reported here is similar to the illustration provided in the EPA TIE saltwater guidance document (U.S. EPA, 1996), where separate treatments of STS and EDTA reduced toxicity in sea urchins exposed to copper-spiked samples from 5 to 2.2 and <2.0 but >1.0 toxic units, respectively.
For the fish, following TIE treatments of the spiked sample, 100% of the toxicity was removed indicating the general success of the TIE process for a matrix that was moderately toxic to this species. Here, the initial response to 100% untreated pore water was 7% survival and survival

increased with successive treatments (STS, 47%; EDTA, 53%; filtration, 80% and *Ulva*, 100%). Filtration and Oasis® SPE steps both resulted in moderate increases in toxicity in the 10% and 25% dilutions. The cause of this response is unclear but it is possible that a toxic constituent of the SPE column eluted into the sample. This effect was noted in evaluating the general pattern of residual toxicity observed in the TIE series (Section 4). Trends towards increasing toxicity in larval fish toxicity occurred following the Oasis® SPE treatment in several spiked samples, as with the urchin tests. It is notable that the apparent reduction in toxicity following the STS treatment of the spiked sample differs from the urchin test where the reduction to fish occurred with EDTA. This suggests different modes of toxic action for these two species since the exposure water was the same in both cases.

3.3.2. Summary of TIE Results by Treatment and Location

Tables 3.3-1 to 3.3-3 summarize the individual dilution results from toxicity testing with the urchin, fish, and sand dollar, respectively, while Tables 3.3-4 to 3.3-6 present a quantitative toxicity reduction analysis of the TIE data for these species. For the dilution results, the data are shaded to indicate a reduction in toxicity relative to the preceding TIE treatment(s), and values are bolded when results are different from the performance controls. As discussed previously, lower dilutions (e.g., 10%) represent less concentrated samples. Where toxicity occurs in the more dilute sample, TIE treatments may be more effective in revealing the most potent sources of toxicity because the additional stresses of other less toxic factors no longer mask the effects of the more potent constituents. For the toxicity reduction data, the sum of toxicity across all dilutions was calculated and compared to the prior treatment result to obtain the percent reduction in toxicity achieved by the treatment.

Purple urchin TIE results. From the synthesis presented for sea urchin tests (Table 3.3-1), it is clear that ammonia was evident as a source of toxicity in most samples and in most dilutions. The next most prevalent signal for reduction in toxicity was from STS, and in some samples the metal toxicity signal was split between STS and EDTA. Evidence of potent contributors to toxicity are represented by embryo-development impairment that occurred in the baseline, pre-TIE 10% pore water concentrations; all pore waters except HP-5 experienced <22% normal development at the 10% concentration (Table 3.3-1). After STS additions, five of these samples (HP-1, HP-4, HP-5, HP-6 and HP-9) yielded >46% normal development, while the reference station (HP-REF) also improved substantially (>44% normal development). Results from the 10% dilution indicate that in samples listed above, metals were the most potent contributor to toxicity. Overall, including all dilutions of these samples, STS accounted for 20% to 62% of the total toxicity removed by TIE treatments (Table 3.3-4). The greatest reduction in total toxicity from the STS treatment occurred in sample HP-6, including reduced toxicity in the 50%, 25% and 10% dilutions. Total and calculated un-ionized ammonia were the lowest in this sample. In other samples, the concentrations of ammonia present until the final TIE treatment were sufficient to limit the degree of metal toxicity that could be detected by the TIE. For HP-2, STS had limited effect, while toxicity was largely removed by EDTA at the 10% concentration. Of the four samples where toxicity did not change with STS (HP-2, HP-3, HP-8 and HP-10) in the10% dilution, HP-3, HP-8 and HP-10 had un-ionized ammonia HQs that were still above the acute effects range (i.e., HQ>1 for 10% of values in Table 3.1-3). Hence, for these three

samples, it was presumed that ammonia toxicity was still sufficient to mask other potential sources of adverse effects addressed by the TIE treatments. As noted previously for the spiked sample, the Oasis® SPE treatment resulted in moderate increases in toxicity.

Fish TIE results. For the fish larvae, which are more tolerant of ammonia than embryo-larval stages of the urchin (LC_{50} =37 mg/L vs. 2 mg/L total ammonia), toxicity was only observed in the 100% pore water samples (Table 3.3-2). No toxicity occurred in HP-2, HP-6, or HP-Ref; these samples had the lowest ammonia concentrations (HQs < 0.2; Table 3.1-3). Of those samples with complete mortality in 100% pore water (HP-3, HP-8, HP-9, HP-10) all had pore water un-ionized ammonia HQs $\geq$ 2. In contrast, only partial mortality was observed when HQ $\leq$ 2. However, in HP-3, HP-8 and HP-10, DO values < 1.0 mg/L were observed, which by itself could cause complete mortality in all treatments prior to the *Ulva* treatment. Therefore, the test was not effective in elucidating other potential toxicants effects in these samples. The *Ulva* treatment restored DO photosynthetically while removing ammonia, restoring conditions necessary for full survival, indicating that there were no residual toxic effects. As with the sea urchin, reduction in toxicity due to toxic constituents other than ammonia (e.g., manganese) might have been masked even if low DO had not been a confounding factor. In one case (HP-9), filtration accounted for a 34% reduction in the total reduction in toxicity (Table 3.3-5). Moderate reductions (53%) in toxicity were also observed following the STS treatment of HP-4. Finally, the high pH treatment did little to alter toxicity because the non-adjusted pHs drifted upward during the course of the test, approaching the 'High pH' treatment values.

Sand dollar results. A follow-on test was conducted with the sand dollar, *D. excentricus*, using fresh pore water re-extracted from stored sediments. Samples chosen for additional testing included HP-4 from the Oil Reclamation Area, and HP-5 and HP-9 from the South Basin. These samples were chosen because they were among the samples that had caused mortality during the fish test that was not fully attributable to ammonia. In this procedure, the original sequence of TIE treatments was repeated, but was accompanied by a reverse sequence where the *Ulva* treatment was applied first to remove ammonia prior to the other treatments.

Dilution results for the sand dollar are presented in Table 3.3-3. Similar patterns to the original urchin exposures were observed, but were somewhat less pronounced than those previously manifested. HP-4, from the Oil Reclamation Area, exhibited lower overall toxicity than in the original test, with no toxicity in the 10% concentration. Interestingly, in the 100% concentration, a large reduction in toxicity occurred only in the *Ulva* treatment when it was the final treatment, but in the *Ulva*-1st treatment, gradual increases in normal development occurred with *Ulva*, STS and EDTA applications. This is similar to the original test, where 29% of the total toxicity was removed by STS. In HP-5 at the 10% concentration, the EDTA-1st and *Ulva* last treatments reduced toxicity by 27% and 24%, respectively (Table 3.3-6). Conversely, when *Ulva* was the first treatment, all of the toxicity was removed. A similar effect was observed for HP-REF at the 50 and 100% dilutions. In HP-9 (10%), small reductions in toxicity occurred through each of the first three treatments (STS, EDTA and filtrations), yielding 54% normal development in the post-filtered sample, and an additional gain of 24% following *Ulva* treatment. Like HP-4, the *Ulva*-1st treatment removed all toxicity in all but the 100% concentration. In the undiluted sample, the combined STS and EDTA treatments reduced effects by 20%.

This follow-on test suggests that the *Ulva* treatment from HP-5 (10% dilution), HP-4 (50% dilution), HP-9 (50% dilution) and HP-REF (100% dilution) removed toxicity. This would indicate that there was no constituent more toxic than ammonia, although it is also possible that the toxicant(s) present in the original samples had diminished relative to ammonia. If this were the case, the results from the urchin test either reflected ultra-sensitivity to certain components of the pore water matrix, possibly due to compromised condition of the animals, or to a greater natural sensitivity in the urchin than in the sand dollar due to factors other than ammonia.

Spatial trends. Regarding TIE responses for each of the four Hunter's Point areas targeted for the study, the Point Avisadero exposures (HP-1 and HP-2), were the least influenced by ammonia, and STS effects and/or EDTA responses occurred. Conversely, the Eastern Wetland (HP-3) was largely affected by ammonia. The Oil Reclamation Area (HP-4), South Basin and Paradise Cove (HP-REF) samples had intermediate ammonia effects. The latter samples also tended to exhibit STS effects (HP-4, HP-5, HP-6, HP-7, HP-9 and HP-REF).

The surface and subsurface samples from Point Avisadero exhibited nearly identical responses to STS, EDTA and *Ulva*, and were non-toxic or minimally toxic to the fish. In South Basin, HP-5 and HP-6 also represented co-located surface and subsurface samples, with substantially lower ammonia concentrations (0.3 vs. 1.3 un-ionized ammonia HQs in the 10% samples). The subsurface sample with lower ammonia exhibited the greater STS signal in the urchin, but was non-toxic to the fish. This indicates that other samples with higher ammonia could also have constituents that would be highly toxic to the urchin larval development, in the absence of ammonia.

4. SYNTHESIS, CONCLUSIONS AND UNCERTAINTY

The most notable finding from the tests with Hunter's Point sediment pore waters was the principal TIE signal revealing the role of ammonia as a source of toxicity. With regard to the potential role of CoPCs, the pattern of reduced toxicity resulting from STS treatments was exhibited principally in the 10% and 25% dilutions. STS is expected to reduce many cationic metals (U.S. EPA 1991, 1996). In fresh water it has been demonstrated to be a most effective TIE treatment for copper, silver and mercury, but it also acts on lead, cadmium and manganese, in more restrictive proportions (Hockett and Mount, 1996). The ability of both STS and EDTA to remove toxicity is dependent on the relationship between the concentrations of the metals that are causing toxicity and the maximum concentrations of STS and EDTA that can be used to complex the metals without themselves causing toxicity. Where metals with high benchmarks such as aluminum and manganese are present at toxic concentrations, the amount of STS and/or EDTA that is used in the test (e.g., quantities tolerable to the test organisms) may be insufficient to react with all of the available metal (Hockett and Mount, 1996).

Measured pore water concentrations of copper, zinc and aluminum in the TIE samples were near or above species-specific benchmarks, and thus could explain changes in toxicity that were observed, particularly in the more dilute STS-treated urchin test exposures (Table 3.1-3). Among

these metals, aluminum appears to present the greatest potential for acute toxicity. The species-specific HQs for aluminum derived using bivalve response data are higher than the water quality criteria HQs, indicating extra-sensitivity in bivalve larval development (and presumably in urchins and sand dollars). Problematically, the effect concentrations may be near the limits of efficient treatment using acceptable doses of STS and EDTA. Aluminum is not frequently associated with toxicity (U.S. EPA, 1997) and EPA TIE guidance documents (U.S. EPA, 1991 and 1996) provide no specific reference to the effectiveness of STS for removing aluminum toxicity; it is listed only as a metal that is chelated by EDTA. Additively, the HQs for copper, zinc and aluminum present the most cogent case for non-ammonia toxicity in urchins. In the fish, where non-ammonia and low DO effect observations were limited to stations HP-1, HP-5 and HP-9, species-specific HQs for copper and zinc were much lower than for the urchin. These values, and the absence of suitable surrogate species data for aluminum effects, preclude the association of this metal group with toxicity in the fish.

Another potential association with the STS/EDTA treatment response in the more dilute samples is the reduced toxicity associated with manganese. Toxicity of manganese to the early life stages of rainbow trout has been reported at concentrations near those measured in the 100% samples. In fact, in all three samples where the larval fish appeared to respond to STS and/or EDTA, manganese species-specific HQs were greater than unity. Assuming the reported bivalve embryo-larval effect concentration is an adequate surrogate for the urchin and sand dollar effects, it appears that sensitivity to manganese was less than observed in the fish. Still, manganese should not be ruled out as a contributor to toxicity in both species. Also, manganese (along with copper) was one of the few analytes that produced HQs greater than unity in both sediment and pore water evaluations using standard benchmarks.

CoPCs aside, variances from optimal ionic concentrations of natural constituents (e.g. salts) can contribute to toxic effects. Bay *et al.* (1993) reviewed some of these factors that may mediate toxicity in echinoderm early life stages, and reported tolerable limits for salinity (>29 ppt) and pHs (< 8.3) for the purple urchin. However, the endpoints cited, such as fertilization and larval pigmentation, are not directly comparable to those used in the current TIE. On the other hand, Fairey *et al.* (1998) report high rates of larval development in the purple urchin with salinities below 28 ppt; this illustrates that the susceptibility of this species may vary from study to study. Ionic imbalance problems have been suggested as contributors to toxicity in both effluent and sediment TIEs (Ho and Caudle, 1997; Adams et al., 2001). In a recent TIE with marine sediments from the Calcasieu River in Louisiana, SAIC found that a high concentration of calcium was the most likely source of toxicity in at least one pore water sample (SAIC, 2002). Because specific TIE treatments have not been developed to address problems of ion imbalance (it is difficult to selectively remove major ions such as calcium) this problem is normally only considered when the traditional TIE treatments fail to remove toxicity. In the current study, residual toxicity appears to have occurred in some samples (most notably HP-4 and HP-10), where measurement of the major ions in these sediments would serve as one first step towards resolving this uncertainty.

Sediment and water quality characteristics that were evaluated to discern potential factors that might influence toxicity (e.g., TOC, SEM:AVS, % fines) do not appear to be major determinants

in affects observed during the TIE exposures. Total Organic Carbon values were all relatively low, as were SEM-AVS values. One possible explanation for the demonstrated deviation from the general rule that AVS controls divalent metal bioavailability is that two of the metals contributing to elevated HQs (Al^{2+}, Mn^{2+}) were not (and typically are not) measured as SEM metals. A recent study presented by O'Day *et al.* (2000) conducted to determine the effectiveness of SEM:AVS in predicting metal toxicity in pore waters from Seaplane Lagoon in San Francisco Bay found that sand dollar embryo larval toxicity was poorly correlated with SEM:AVS. The study reported that the SEM:AVS toxicity model could be applicable for cadmium, and only partially valid for zinc, while the bioavailability of other metals is mostly controlled by factors other than AVS. O'Day and colleagues surmised that pore water variables such as oxidation potential, pH and ionic strength, along with consideration for clay-binding properties, carbonates, oxyhydroxides and sulfur oxidation and reduction reactions in the sediments will ultimately lead to better methods to predict metal toxicity.

While the current TIE has provided valuable insight with regard to the relative contributions of metals vs. ammonia, there were no signals that suggested acute toxicity associated with the sparse benchmark exceedences of CoPC organic contaminants. This was expected, as the larger exceedences were for PCBs, and PCBs are not generally contributors to acute effects. The potential for some toxicity associated with the Oasis column elutions requires further investigation. Because this effect was not observed in a previous spiking trial with fish larvae conducted antecedent to this study, it is likely that the characteristics of individual pore water matrices mediated the response. It is possible that some residual toxicity (remaining after the *Ulva* treatment) may have been due to effects associated with the Oasis column. Optimizing an SPE column to effectively remove more organic contaminants than the current standard C_{18} column would serve as a significant advance in TIE technology.

Another objective of the TIE study was to evaluate the effect of sediment sampling depth on potential sources of toxicity. In the samples from Point Avisadero (HP-1 and HP-2), surface and subsurface toxicity did not differ with depth. TIE responses and HQs were nearly identical for both samples. In contrast, toxicity to the fish in the South Basin samples did vary with vertical distribution (HP-5 and H-6). Additionally, TIE responses were different. The deeper sample produced a greater reduction in toxicity following STS treatment than did the shallower sample. The surface sample demonstrated a stronger *Ulva* signal. These differences are consistent with the much higher ammonia HQs derived for the surface sample. While metal HQs are similar between samples, it is likely that the lower ammonia concentration in the deeper station (the only station with a total ammonia HQ <1) allowed for expression of metal toxicity that was masked in the surface sediment sample.

Ultimately, the results of TIE studies must be interpreted within a risk assessment framework, as supporting ancillary data to the overall weight-of evidence process that broadly encompasses all that is known regarding effects on aquatic receptors at the site. All laboratory exposures employed for toxicity testing purposes are limited representations of potential field conditions. Bulk sediment tests reflect the bioavailability of contaminants relative to response thresholds for the species tested. SWI tests represent exposure conditions likely to be experienced by early life stages of benthic organisms, such as the sea urchin. Pore water tests represent exposure

conditions that infaunal organisms might experience, and application of a sensitive bioassay such as the sea urchin larval development test serves as a surrogate for infaunal species that could potentially have a similar level of sensitivity. As noted by Allan et al. (2001), pore water tests frequently result in an order of magnitude, greater toxicity than bulk sediment tests, but these responses prompt the need to evaluate underlying causes, particularly when they are correlated with observed complex changes in the benthic community structure in field studies (Adams et al., 2000). The greatest advantage of the TIE results with sea urchins is that the sensitive responses they provide allow observations of toxicity reduction for multiple potential classes of toxicants that may be present in varying degrees of potency.

An interpretive summary of the Hunter's Point TIE is provided in Table 4.1-1. Results from test with each species are tabulated, carried forward principally from Tables 3.3-4 to 3.3-6. These TIE responses, were paired with species specific HQs. Pore water HQs and sediment HQs that provide additional information regarding potential sources of toxicity are noted in the final column as they provide less specific correlation with the pore water tests that were conducted. General conclusions can be summarized as follows:

- Levels of toxicity observed in the pore water exposures were substantially higher than in bulk sediment and Sediment Water Interface toxicity tests, where minimal toxicity occurred. Known differences between the tolerance limits of the species tested as well as differences in exposure concentrations account for these differences. For the TIE study sediment pore water was used as the test media, thus representing a potential worse-case scenario for exposure. Results of the TIE study should contribute as ancillary data in identifying potential sources of toxicity within the overall weight of evidence process utilized for Hunters Point Validation Study.

- Toxicity did not differ substantially with depth in the two stations where surface and subsurface sediments were represented.

- Very high oxygen demand in the pore water samples offers clues to the biogeochemical properties governing the bioavailability of the toxicants. Ammonia has a relatively high oxygen demand (consumes oxygen through transformation to nitrite and nitrate), but it is likely that the formation of metal oxides and sulfides, as well as biotic factors (i.e., bacteria) contributed to the oxygen depletion in the samples.

- Toxicity reductions due to STS reduction and EDTA chelation observed in all species were correlated with elevated pore water concentrations of metals, especially aluminum, copper, manganese and zinc. A similar correlation was also observed at the reference station, indicating that metals-related toxicity may not be site-specific.

- Ammonia toxicity was the predominant source of toxicity removed by TIE procedures for urchins, sand dollars and fish, but other contributors to effects were observed, particularly with the purple urchin. Follow-on testing with sand dollars confirmed that factor(s) other than ammonia contributed to toxicity.

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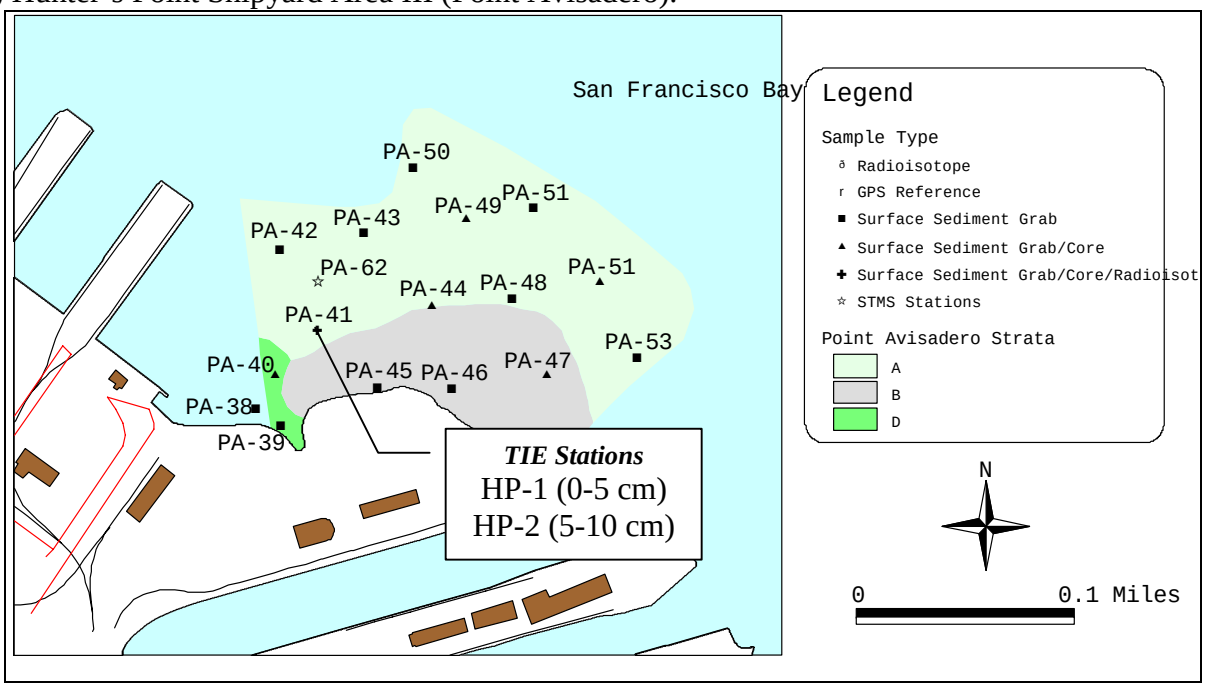
Figure 2.1-1. Location of Hunter's Point Validation Study sampling locations selected for the Hunter's Point TIE investigation[1].

a) Hunter's Point Shipyard Area III (Point Avisadero).



1 – Locations from the Hunter's Point Validation Study Work Plan, Draft Final (Battelle *et al.*, 2000a)

b) Hunter's Point Shipyard Area VIII (Eastern Wetland).

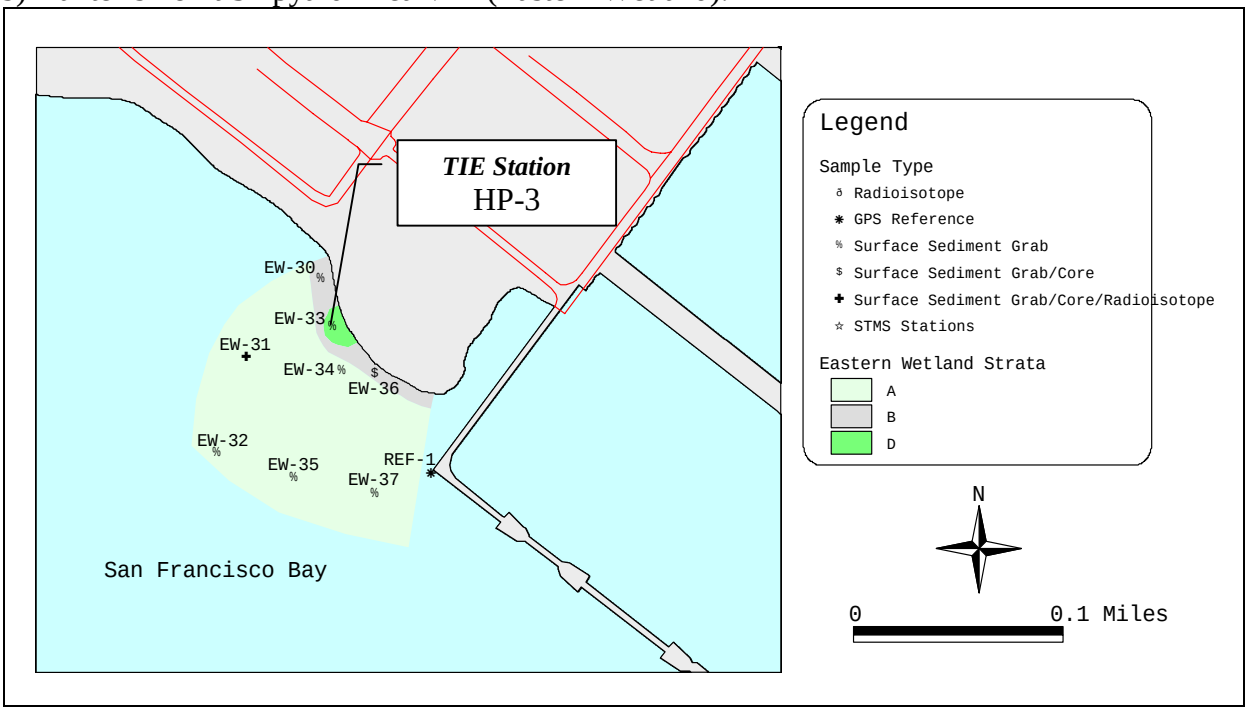
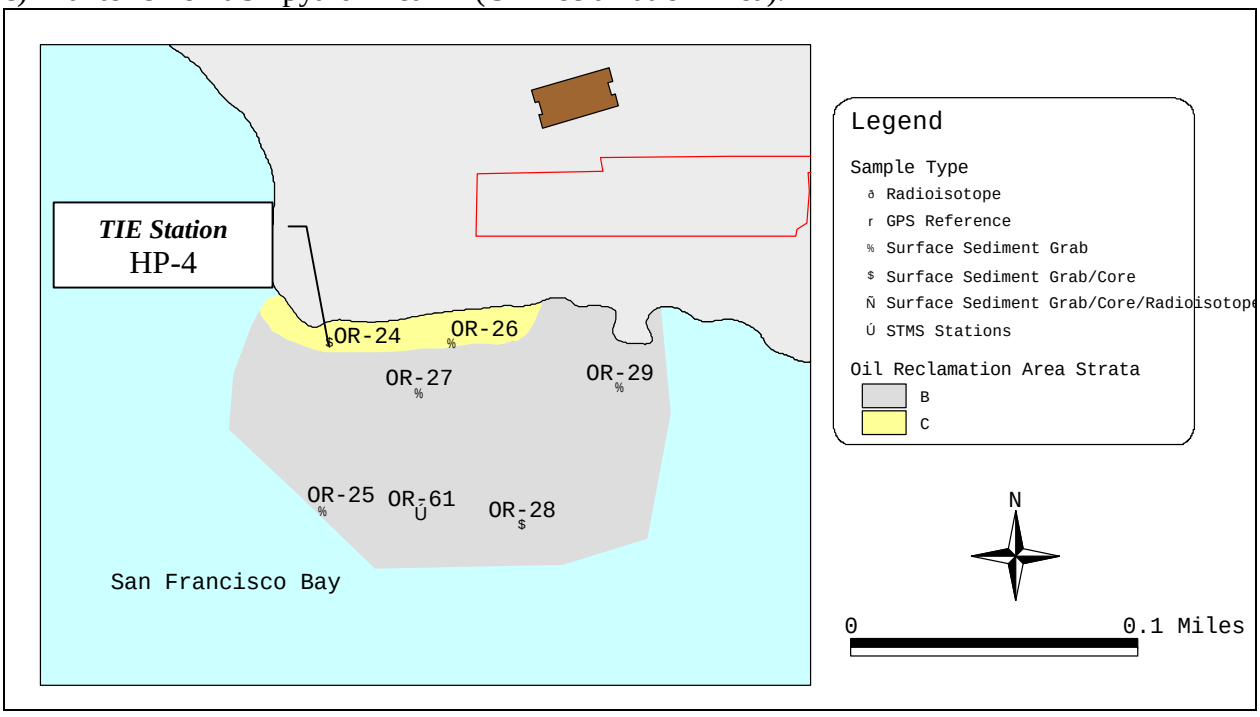


Figure 2.1-1. continued.

c) Hunter's Point Shipyard Area IX (Oil Reclamation Area).



d) Hunter's Point Shipyard Area X (South Basin).

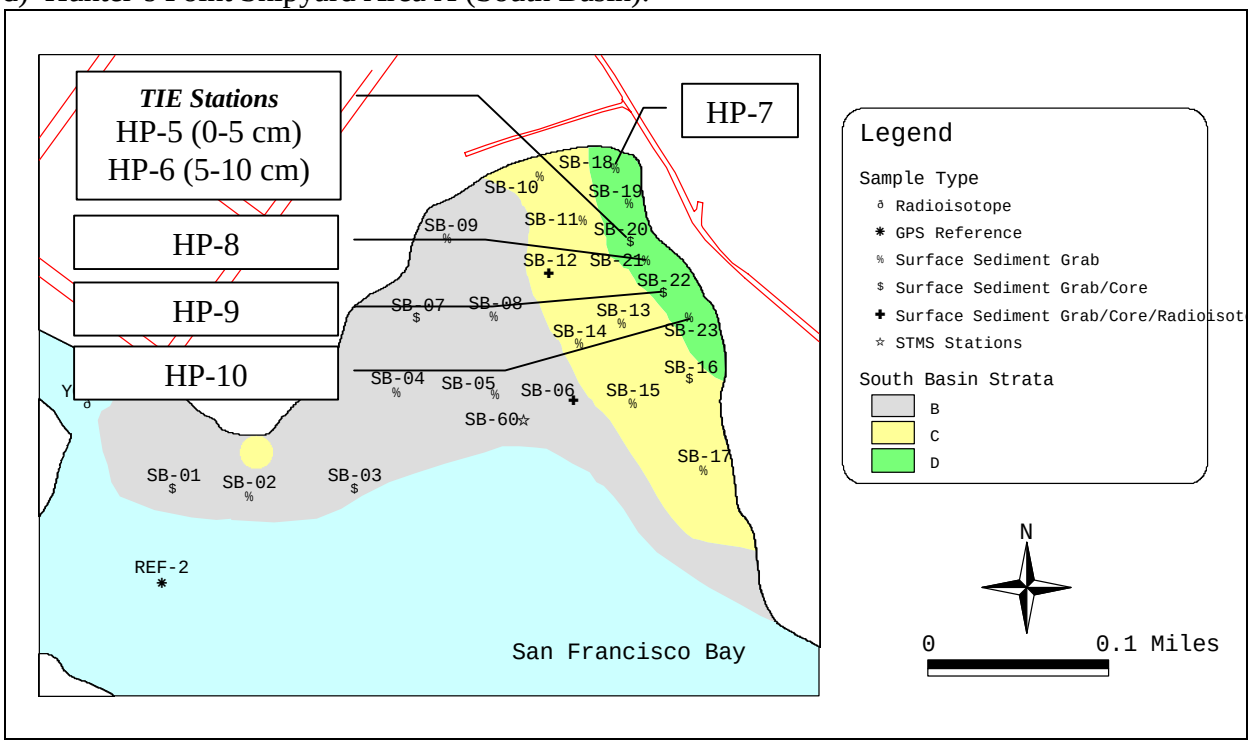


Figure 2.3-1. TIE fractionation procedure for the Hunter's Point TIE investigation.

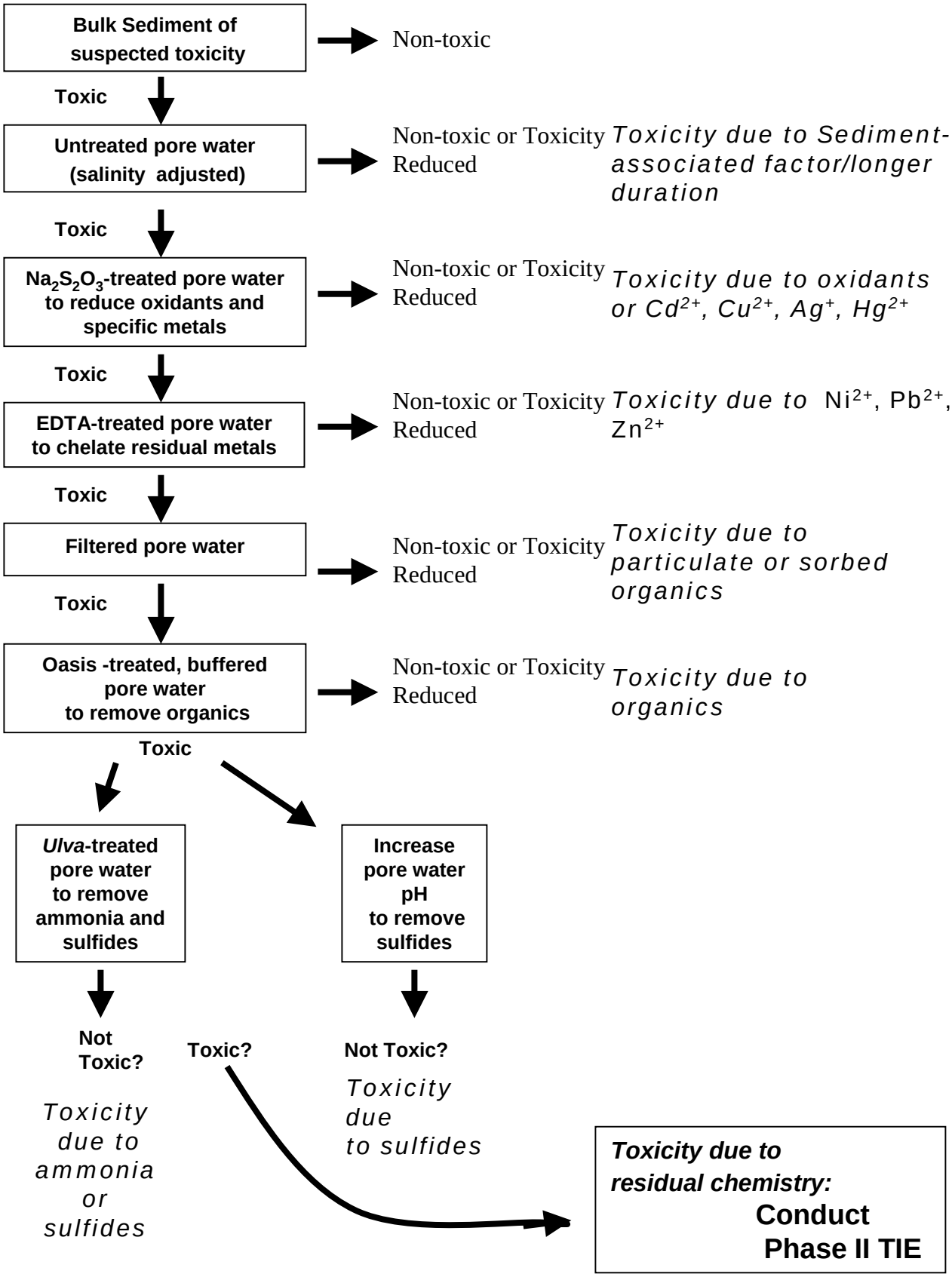


Table ES-1. Summary of findings from the Hunter's Point Toxicity Identification Evaluation (TIE).

Area	SAIC TIE ID	Treatment(s) that Reduced Pore Water Toxicity and Associated Probable Toxicant(s)[1]		
		Fish	**Urchin**	**Sand Dollar**
Point Avisadero	HP-1	STS>EDTA- Manganese, Copper	*Ulva* -NH_4> STS>EDTA- metals	ND
Point Avisadero	HP-2	NT	*Ulva* -NH_4> EDTA=STS- metals	ND
Eastern Wetland	HP-3	Low DO>*Ulva* - NH_4	*Ulva* -NH_4> EDTA- metals	ND
Oil Reclamation	HP-4	STS- Aluminum, Zinc, Copper	*Ulva* -NH_4> STS- metals	*Ulva* -NH_4 *Ulva* -NH_4>STS>EDTA-Aluminum, Zinc, Copper[2]
South Basin	HP-5	Filtered-particle fraction> STS-Manganese, Copper= *Ulva* -NH_4	*Ulva*- NH_4> STS- metals	*Ulva* -NH_4> EDTA>Filtration *Ulva* -NH_4>STS-Aluminum, Copper, Zinc[2]
South Basin	HP-6	NT	STS- metals> *Ulva* -NH_4>EDTA- metals =Filtration- particle fraction	ND
South Basin	HP-7	NT	*Ulva* -NH_4> STS- Aluminum, Copper, Zinc	ND
South Basin	HP-8	Low DO>*Ulva* -NH_4	*Ulva* -NH_4	ND
South Basin	HP-9	*Ulva* -NH_4> Filtered-particle fraction> EDTA- Manganese, Copper	*Ulva* -NH_4> STS- metals	*Ulva* -NH_4>Filtration-particle fraction=EDTA>STS- Aluminum, Zinc, Copper *Ulva* -NH_4>STS>EDTA-Aluminum, Zinc, Copper[2]
South Basin	HP-10	Low DO>*Ulva* -NH_4	*Ulva* -NH_4	ND
	HP-SPIKE	STS/EDTA- Copper Filtrtion-particle fraction Ulva- Copper, NH_4	Ulva-NH_4/EDTA-Copper	ND
Paradise Cove	HP-REF	NT	*Ulva* -NH_4=STS-Aluminum, Copper, Zinc>Filtration-particle fraction	*Ulva* -NH_4=EDTA>STS-Aluminum, Copper, Zinc *Ulva* -NH_4=STS>EDTA-Aluminum, Copper, Zinc[2]

1 - in order of percent of overall toxicity removed (Table 3.3-4, 3.3-5 and 3.3-6); see text for probable CoCs.

2 - observed in reverse treatment

NT = not toxic; ND = no data

Table 2.2-1. Selection of benchmarks used in calculating sediment Hazard Quotients for the Hunter's Point TIE investigation.

		Marine Sediment						Selected[1]	
Class	Analyte	ER-M	PEL	AET-H	AET-L	SQAL	EPA	BM	Source
MET	Aluminum								
MET	Antimony				9.3			9.3	AET-L
MET	Arsenic	70	42	700	57			70	ER-M
MET	Barium								
MET	Cadmium	9.6	4.2	9.6	5.1			9.6	ER-M
MET	Chromium	370	160	270	260			370	ER-M
MET	Cobalt				10			10	AET-L
MET	Copper	270	108	1300	390			270	ER-M
MET	Iron								
MET	Lead	218	112	660	450			218	ER-M
MET	Manganese				260			260	AET-L
MET	Mercury							0.7	ER-M
MET	Molybdenum								
MET	Nickel	52	43					52	ER-M
MET	Selenium				1.0			1.0	AET-L
MET	Silver	3.7	1.7	6.1	6.1			3.7	ER-M
BT	DBT								
BT	MBT								
BT	TBT				3.4			3.4	AET-L
BT	TTBT								
BT	Total Butyltins								
MET	Vanadium								
MET	Zinc	410	271	1600	410			410	ER-M
MET	SEM-AVS						5.0	5	EPA
PAH	2-Methylnaphthalene	670	201	1900	670			670	ER-M
PAH	Acenaphthene	500	89	2000	500	1300		500	ER-M
PAH	Acenaphthylene	640	128	1300	1300			640	ER-M
PAH	Anthracene	1100	245	13000	960			1100	ER-M
PAH	Benzo(a)anthracene	1600	693	5100	1600			1600	ER-M
PAH	Benzo[a]pyrene	1600	763	3600	1600			1600	ER-M
PAH	Benzo[b]fluoranthene			9900	3600			9900	AET-H
PAH	Benzo[ghi]perylene			2600	720			2600	AET-H
PAH	Benzo[k]fluoranthene			9900	3600			9900	AET-H
PAH	Chrysene	2800	846	9200	2800			2800	ER-M
PAH	Dibenz[a,h]anthracene	260	135	970	230			260	ER-M
PAH	Fluoranthene	5100	1494	30000	2500	6200		5100	ER-M
PAH	Fluorene	540	144	3600	540	540		540	ER-M
PAH	Indeno[1,2,3-cd]pyrene			2600	690			2600	AET-L
PAH	Naphthalene	2100	391	2700	2100	470		2100	ER-M
PAH	Phenanthrene	1500	544	6900	1500	1800		1500	ER-M
PAH	Pyrene	2600	1398	16000	3300	97000		2600	ER-M
PAH	Total LMW (L) PAHs	3160	1442	24000	5200			3160	ER-M
PAH	Total HMW (H) PAHs	9600	6676	69000	17000			9600	ER-M
PAH	Total PAHs	44792	16770					44792	ER-M
PCB	Total PCBs	180	189	3100	1000			180	ER-M
PST	2,4'-DDD	27	7.8	43	16			27	ER-M
PST	2,4'-DDE	27	374	15	9.0			27	ER-M
PST	2,4'-DDT	27	4.8	34	34			27	ER-M
PST	4,4'-DDD	27	7.8	43	16			27	ER-M
PST	4,4'-DDE	27	374	15	9.0			27	ER-M
PST	4,4'-DDT	27	4.8	34	34			27	ER-M
PST	alpha-Chlordane		4.8					4.8	PEL
PST	Dieldrin		4.3					4.3	PEL
PST	Endosulfan II					14		14	SQAL
PST	Endrin					42		42	SQAL
PST	gamma-Chlordane		4.8					4.8	PEL
PST	Heptachlor				0.3			0.3	AET-L

1- Benchmarks were selected in the following order of priority:

Marine Sediment: 1) ER-M; 2) PEL; 3) AET-H/L; 4) SQAL; 5) EPA.

Units: Metals = µg/g; PCBs, Pesticides (PST), PAHs = ng/g; AVS, SEM= µM/g.

LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995); (methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene).

HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995); (benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene).

Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2.

ER-M = NOAA Effects Range-Median (Long et al. 1995 in U.S. EPA 1997).

PEL = Threshold Effects Levels (FDEP 1994 in U.S. EPA 1997).

AET-L/H = Apparent Effects Threshold Low/High (Barrick et al. 1988 in U.S. EPA 1997).

SQAL = EPA Sediment Quality Advisory Levels, based on 1% TOC (U.S. EPA 1997).

EPA = EPA SEM-AVS sediment quality screening value,µM/g dry weight (U.S. EPA 1997).

Table 2.2-2. Selection of benchmarks used in calculating pore water Hazard Quotients for the Hunter's Point TIE investigation.

		Water Quality Criteria		Selected Sediment[2]			Estimated	Selected Pore water[1]	
Class	Analyte	WQC-SA	WQC-FA	BM	Source	Koc	Pore water	BM	Source
MET	Aluminum		750					750	WQC-FA
MET	Arsenic	69	360	70	ER-M			69	WQC-SA
MET	Cadmium	42	3.9	9.6	ER-M			42	WQC-SA
MET	Chromium	1100	16	370	ER-M			1100	WQC-SA
MET	Copper	4.8	18	270	ER-M			4.8	WQC-SA
MET	Iron								
MET	Lead	210	83	218	ER-M			210	WQC-SA
MET	Manganese		1000	260	AET-L			1000	WQC-FA
MET	Nickel	74	1400	52	ER-M			74	WQC-SA
MET	Silver	1.9	4.1	3.7	ER-M			1.9	WQC-SA
MET	Zinc	90	120	410	ER-M			90	WQC-SA
MET	SEM-AVS			5	EPA				
PAH	2-Methylnaphthalene	300		670	ER-M	8.0E+3	8.4	300	WQC-SA
PAH	Acenaphthene		1700	500	ER-M	7.1E+3	7.0	1700	WQC-FA
PAH	Acenaphthylene	300		640	ER-M	9.6E+3	6.7	300	WQC-SA
PAH	Anthracene	300		1100	ER-M	3.0E+4	3.7	300	WQC-SA
PAH	Benzo(a)anthracene	300		1600	ER-M	4.0E+5	0.4	300	WQC-SA
PAH	Benzo[a]pyrene	300		1600	ER-M	1.0E+6	0.2	300	WQC-SA
PAH	Benzo[b]fluoranthene	300		9900	AET-H	1.2E+6	0.8	300	WQC-SA
PAH	Benzo[ghi]perylene	300		2600	AET-H	3.9E+6	6.7E-2	300	WQC-SA
PAH	Benzo[k]fluoranthene			9900	AET-H	1.2E+6	0.8	0.8	estimated
PAH	Chrysene	300		2800	ER-M	4.0E+5	0.7	300	WQC-SA
PAH	Dibenz[a,h]anthracene	300		260	ER-M	3.8E+6	6.9E-3	300	WQC-SA
PAH	Fluoranthene		3980	5100	ER-M	1.1E+5	4.7	3980	WQC-FA
PAH	Fluorene	300		540	ER-M	1.4E+4	3.9	300	WQC-SA
PAH	Indeno[1,2,3-cd]pyrene	300		2600	AET-L	3.4E+6	7.5E-2	300	WQC-SA
PAH	Naphthalene		2300	2100	ER-M	2.0E+3	104	2300	WQC-FA
PAH	Phenanthrene		30	1500	ER-M	3.0E+4	5.0	30	WQC-FA
PAH	Pyrene	300		2600	ER-M	1.1E+5	2.5	300	WQC-SA
PAH	Total LMW (L) PAHs	300		3160	ER-M			300	WQC-SA
PAH	Total HMW (H) PAHs	300		9600	ER-M			300	WQC-SA
PAH	Total PAHs	300		44792	ER-M	7.6E+4	59	300	WQC-SA
PCB	Total PCBs		2	180	ER-M	2.7E+6	6.7E-3	2.0	WQC-FA
PST	2,4'-DDD			27	ER-M	9.9E+5	2.7E-3	2.7E-3	estimated
PST	2,4'-DDE			27	ER-M	4.4E+6	6.1E-4	6.1E-4	estimated
PST	2,4'-DDT			27	ER-M	4.4E+6	6.1E-4	6.1E-4	estimated
PST	4,4'-DDD		0.6	27	ER-M	9.9E+5	2.7E-3	0.6	WQC-FA
PST	4,4'-DDE		1050	27	ER-M	4.4E+6	6.1E-4	1050	WQC-FA
PST	4,4'-DDT		1.1	27	ER-M	4.4E+6	6.1E-4	1.1	WQC-FA
PST	alpha-Chlordane			4.8	PEL	2.5E+6	2.0E-4	2.0E-4	estimated
PST	Dieldrin	0.71	2.5	4.3	PEL	1.9E+5	2.3E-3	0.7	WQC-SA
PST	Endosulfan II			14	SQAL	1.1E+4	0.1	0.1	estimated
PST	Endrin	3.7E-2	0.2	42	SQAL	9.4E+4	4.5E-2	3.7E-2	WQC-SA
PST	gamma-Chlordane			4.8	PEL	1.6E+6	2.9E-4	2.9E-4	estimated
PST	Heptachlor	5.3E-2	0.5	0.3	AET-L	2.5E+6	1.2E-5	5.3E-2	WQC-SA
AMM	Un-ionized Ammonia	0.23						0.23	WQC-SA

1- Benchmarks (units = µg/L (mg/L for AMM)) were selected in the following order of priority:
1) WQC-SA; 2) WQC-FA; 3) Estimated from sediment benchmark using equilibrium partitioning relationship (Di Toro *et al.,* 1992).
WQC-SA = saltwater acute (U.S. EPA 1999 [metals, dieldrin, endrin, heptachlor], NOAA 1999);
WQC-FA = freshwater acute (NOAA 1999); Estimated = sed. BM/(Koc*0.01) .
WQC-SA reported for Chromium VI.
2- See Table 2.2-1 for sediment benchmark selection process and definitions.
LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene).
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene).
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2.

Table 2.2-3. Summary of species-specific acute effects from water-only exposures for potentially toxic analytes in the Hunter's Point TIE investigation.

A. Contaminant effect concentrations.

	Purple Urchin *S. purpuratus* EC_{50} (µg/L)	Silverside fish *M. menidia* LC_{50} (µg/L)	Sand Dollar *D. excentricus* EC_{50} (µg/L)	Bivalves EC_{50} (µg/L)
Manganese	NA	3680 Rainbow trout (7)	NA	14,000-19,000 *C. virginica* embryos (8)
Copper	8 (2)	136 (3)	19.8 (4)	NA
Zinc	19 (2)	3,900 (2)	NA	
Aluminum	200 (10)	NA	NA	227 (9)
Barium			NA	200-900 *M. californicus* (4)
Sodium arsenite as Arsenic III	NA	16,000 (5)	NA	326 (*C. gigas* embryo) (6)
Fluoranthene[1]	NA	> 212 (saturation)	NA	> 212 (saturation) *M. lateralis*

1 - Spehar et al., 1999.
2 - summarized in Bay et al., 1993; geometric mean of three values.
3 - Cardin, 1982 in U.S. EPA, 1985a, EPA440/5-84-031; geometric mean of seven values derived with larvae in flow through tests with measured concentrations.
4 - Bailey et al., 1995.
5 - Cardin, 1982 in U.S. EPA, 1985b, EPA440/5-84-033, January 1985; nominal concentrations from a static test with juvenile fish.
6 - Martin et al., 1981 in U.S. EPA, 1985b, EPA440/5-84-033, January, 1985.
7 - Stubblefield et al., 1997.
8 – Calabrese et al., 1973.
9 – Wilson and Hyne, 1997.
10 – determined using the sea urchin, *Arbacia punctulata*; Waterman, 1937.
NA: No values available

B. Ammonia effect concentrations.

	E. estuarius EC_{50} (mg/L)	*S. purpuratus* EC_{50} (mg/L)	*D. excentricus* EC_{50} (mg/L)	*M. beryllina* EC_{50} (mg/L)
Total Ammonia	>60 [1]	2.0-3.5 [2] 1.25-3.26 @ pH 8.1-8.4 [3]		37.6 [4]
Un-ionized Ammonia	> 0.8 [1]	0.06 0.03-0.08 [2] 0.079-0.108 [3]	0.058 [5]	1.1-1.8 @ pH 7.9-8.6 [3]

1 – U.S. EPA, 1993.
2 – Battelle, 2000b.
3 - Greenstein et.al, 1995.
4 - U.S. EPA, 1986.
5 - Bay et al., 1993.

Table 2.4-1. Summary of test conditions for acute water-only toxicity tests with the silverside *Menidia menidia*[a], the purple sea urchin *Strongylocentrotus purpuratus*[b] and the sand dollar *Dendraster excentricus*[b].

	M. menidia	*S. purpuratus*	*D. excentricus*
Test Type	Static non-renewal	Static non-renewal	Static non-renewal
Test Duration	24 hr[1]	72 hr	72 hr
No. Replicates/Treatment	3	3	3
No. Organisms/Chamber	5	250 eggs/125,000 sperm	250 eggs/125,000 sperm
Test Chambers	20 mL vial	20 mL vial	20 mL vial
Test concentrations	2 (50, 100%)	4 (10, 25, 50, 100%)	4 (1, 10, 50, 100%)
Photoperiod	16:8	16:8	16:8
Age/Size of Test Organisms	1 day pre-hatch	~ 1 hr old	~ 1 hr old
Volume of Overlying Water	20 mL	10 mL	10 mL
Type of Water	clean seawater	clean seawater	clean seawater
Bay Feeding/Chamber	none	none	none
Endpoint	survival	normal dev't	normal dev't
Physical measurements[2]	Dissolved oxygen, pH ammonia, temp.	Dissolved oxygen, pH ammonia, temp.	Dissolved oxygen, pH ammonia, temp.
Acceptance Criteria	80% survival in control	80% normal dev't in control	80% normal dev't in control
Test Temperature[2]	18.9-21.6 ^{o}C	18.9-21.6 ^{o}C	13.6-16.9 ^{o}C
Dissolved Oxygen[2, 3]	0.5-7.6	0.5-7.6	1.0-7.9
pH[2]	7.2-8.6	7.2-8.6	7.9-8.5
Salinity[2]	27-34 ppt	27-34 ppt	32-38 ppt

[a] U.S. EPA, 1996.
[b] U.S. EPA, 1995.
1 - Test duration shorter than standard method (48 hr) to be compatible with TIE methodology.
2 - Measured for each treatment prior to addition of test organisms, as required to monitor stability and after test completion (final). Final water quality measurements reported as most representative of test conditions. Measurements not available for *M. menidia*; *S. purpuratus* measurements reported as test values for both species conducted on same days with aliquots taken from the same sample.
3 - Samples with DO < 7 mg/L at test start were oxygenated to >18mg/L with pure oxygen.

Table 2.4-2. Contaminants measured in sediments and pore waters for the Hunter's Point TIE investigation.

Class[1]	Analyte	Method	Description[2]	Units (dry wt.)	MDL[3]	Laboratory RL[3]
A. Sediment						
BT	DBT	SW3050B/6010B	ICP	µg/kg	1.9	1.7
BT	MBT	SW3050B/6010B	ICP	µg/kg	1.00	1.7
BT	TBT	SW3050B/6010B	ICP	µg/kg	2.7	3.4
BT	TTBT	SW3050B/6010B	ICP	µg/kg	2.4	1.7
MET	Aluminum	SW3050B/6010B	ICP	mg/kg	2.4	15.9
MET	Antimony	SW3050B/6010B	ICP	mg/kg	3.0E-2	3.0E-2
MET	Arsenic	SW3050B/6010B	ICP	mg/kg	6.8E-2	1.3
MET	Barium	SW3050B/6010B	ICP	mg/kg	1.8E-2	0.19
MET	Cadmium	SW3050B/6010B	ICP	mg/kg	1.8E-2	0.60
MET	Chromium	SW3050B/6010B	ICP	mg/kg	0.51	1.3
MET	Cobalt	SW3050B/6010B	ICP	mg/kg	5.3E-2	0.13
MET	Copper	SW3050B/6010B	ICP	mg/kg	0.24	0.30
MET	Iron	SW3050B/6010B	ICP	mg/kg	0.56	32.0
MET	Lead	SW3050B/6010B	ICP	mg/kg	0.20	0.16
MET	Manganese	SW3050B/6010B	ICP	mg/kg	7.4E-2	0.30
MET	Mercury	SW7471A	Cold Vapor	mg/kg	2.1E-3	6.0E-3
MET	Molybdenum	SW3050B/6010B	ICP	mg/kg	3.9E-2	0.25
MET	Nickel	SW3050B/6010B	ICP	mg/kg	3.9E-2	1.0
MET	Selenium	SW3050B/6010B	ICP	mg/kg	0.13	1.3
MET	Silver	SW3050B/6010B	ICP	mg/kg	6.6E-2	0.13
MET	Vanadium	SW3050B/6010B	ICP	mg/kg	0.35	0.60
MET	Zinc	SW3050B/6010B	ICP	mg/kg	0.11	1.3
PAH	2-Methylnaphthalene	SW3540/8270C-Low	GC/ECD	µg/kg	4.0E-2	1.1
PAH	Acenaphthene	SW3540/8270C-Low	GC/ECD	µg/kg	4.0E-2	1.1
PAH	Acenaphthylene	SW3540/8270C-Low	GC/ECD	µg/kg	3.0E-2	1.1
PAH	Anthracene	SW3540/8270C-Low	GC/ECD	µg/kg	3.0E-2	1.1
PAH	Benzo(a)anthracene	SW3540/8270C-Low	GC/ECD	µg/kg	6.0E-2	1.1
PAH	Benzo[a]pyrene	SW3540/8270C-Low	GC/ECD	µg/kg	5.0E-2	1.1
PAH	Benzo[b]fluoranthene	SW3540/8270C-Low	GC/ECD	µg/kg	3.0E-2	1.1
PAH	Benzo[ghi]perylene	SW3540/8270C-Low	GC/ECD	µg/kg	4.0E-2	1.1
PAH	Benzo[k]fluoranthene	SW3540/8270C-Low	GC/ECD	µg/kg	3.0E-2	1.1
PAH	Chrysene	SW3540/8270C-Low	GC/ECD	µg/kg	3.0E-2	1.1
PAH	Dibenz[a,h]anthracene	SW3540/8270C-Low	GC/ECD	µg/kg	8.0E-2	1.1
PAH	Fluoranthene	SW3540/8270C-Low	GC/ECD	µg/kg	4.0E-2	1.1
PAH	Fluorene	SW3540/8270C-Low	GC/ECD	µg/kg	4.0E-2	1.1
PAH	Indeno[1,2,3-cd]pyrene	SW3540/8270C-Low	GC/ECD	µg/kg	7.0E-2	1.1
PAH	Naphthalene	SW3540/8270C-Low	GC/ECD	µg/kg	1.3	1.1
PAH	Phenanthrene	SW3540/8270C-Low	GC/ECD	µg/kg	3.0E-2	1.1
PAH	Pyrene	SW3540/8270C-Low	GC/ECD	µg/kg	4.0E-2	1.1
PAH	Total PAH	SW3540/8270C-Low	GC/ECD	µg/kg	2.0	18.8

Class[1]	Analyte	Method	Description[2]	Units (dry wt.)	MDL[3]	Laboratory RL[3]
PCB	PCB 101	SW3540C/8089	GC/ECD	µg/kg	1.0	8.9
PCB	PCB 105	SW3540C/8090	GC/ECD	µg/kg	9.0E-2	0.88
PCB	PCB 110	SW3540C/8091	GC/ECD	µg/kg	0.11	0.89
PCB	PCB 118	SW3540C/8092	GC/ECD	µg/kg	0.12	0.89
PCB	PCB 126	SW3540C/8093	GC/ECD	µg/kg	0.14	0.88
PCB	PCB 128	SW3540C/8094	GC/ECD	µg/kg	0.19	0.89
PCB	PCB 129	SW3540C/8095	GC/ECD	µg/kg	8.0E-2	0.88
PCB	PCB 138	SW3540C/8096	GC/ECD	µg/kg	0.96	8.9
PCB	PCB 153	SW3540C/8097	GC/ECD	µg/kg	1.4	8.9
PCB	PCB 170	SW3540C/8098	GC/ECD	µg/kg	0.95	8.9
PCB	PCB 18	SW3540C/8099	GC/ECD	µg/kg	8.0E-2	0.89
PCB	PCB 180	SW3540C/8100	GC/ECD	µg/kg	1.0	8.9
PCB	PCB 187	SW3540C/8101	GC/ECD	µg/kg	0.93	8.8
PCB	PCB 195	SW3540C/8102	GC/ECD	µg/kg	9.0E-2	0.89
PCB	PCB 206	SW3540C/8103	GC/ECD	µg/kg	9.0E-2	0.89
PCB	PCB 209	SW3540C/8104	GC/ECD	µg/kg	9.0E-2	0.88
PCB	PCB 28	SW3540C/8105	GC/ECD	µg/kg	0.11	0.88
PCB	PCB 44	SW3540C/8106	GC/ECD	µg/kg	0.10	0.88
PCB	PCB 52	SW3540C/8107	GC/ECD	µg/kg	0.11	0.89
PCB	PCB 66	SW3540C/8108	GC/ECD	µg/kg	0.12	0.88
PCB	PCB 77	SW3540C/8109	GC/ECD	µg/kg	0.16	0.89
PCB	PCB 8	SW3540C/8110	GC/ECD	µg/kg	0.16	0.89
PST	2,4'-DDD	SW3540C/8081A	GC/ECD	µg/kg	0.10	0.88
PST	2,4'-DDE	SW3540C/8081A	GC/ECD	µg/kg	0.13	0.89
PST	2,4'-DDT	SW3540C/8081A	GC/ECD	µg/kg	0.12	0.89
PST	4,4'-DDD	SW3540C/8081A	GC/ECD	µg/kg	0.10	0.89
PST	4,4'-DDE	SW3540C/8081A	GC/ECD	µg/kg	9.0E-2	0.89
PST	4,4'-DDT	SW3540C/8081A	GC/ECD	µg/kg	9.0E-2	0.89
PST	alpha-Chlordane	SW3540C/8081A	GC/ECD	µg/kg	7.0E-2	0.89
PST	Dieldrin	SW3540C/8081A	GC/ECD	µg/kg	0.10	0.89
PST	Endosulfan II	SW3540C/8081A	GC/ECD	µg/kg	0.10	0.88
PST	Endrin	SW3540C/8081A	GC/ECD	µg/kg	9.0E-2	0.88
PST	gamma-Chlordane	SW3540C/8081A	GC/ECD	µg/kg	8.0E-2	0.89
PST	Heptachlor	SW3540C/8081A	GC/ECD	µg/kg	8.0E-2	0.89
SEM	Acid Volatile Sulfide	EPA 1991 Draft		µM/g	0.33	0.33
SEM	Copper	6010		µM/g	6.6E-4	6.6E-4
SEM	Lead	6010		µM/g	1.0E-4	1.0E-4
SEM	Nickel	6010		µM/g	3.7E-4	3.7E-4
SEM	Zinc	6010		µM/g	1.2E-3	1.2E-3
SEM[5]	Cadmium	6010		µM/g	3.0E-5	3.0E-5
TOC	Total Organic Carbon	EPA 9060		mg/kg	76.8	100.0

Class[1]	Analyte	Method	Description[2]	Units (dry wt.)	MDL[3]	Laboratory RL[3]
B. Pore Water						
MET	Aluminum	SW846 6010B	ICP/MS	µg/L	42.9	200
MET	Arsenic	SW846 6010B	ICP/MS	µg/L	1.7	10
MET	Cadmium	SW846 6010B	ICP/MS	µg/L	0.54	5
MET	Chromium	SW846 6010B	ICP/MS	µg/L	0.89	10
MET	Copper	SW846 6010B	ICP/MS	µg/L	1.4	10
MET	Iron	SW846 6010B	ICP/MS	µg/L	42.4	100
MET	Lead	SW846 6010B	ICP/MS	µg/L	8	15
MET	Manganese	SW846 6010B	ICP/MS	µg/L	1.2	15
MET	Nickel	SW846 6010B	ICP/MS	µg/L	2.4	10
MET	Silver	SW846 6010B	ICP/MS	µg/L	2.2	10
MET	Zinc	SW846 6010B	ICP/MS	µg/L	8.6	20

1 - MET = metals; PAH = polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyl; PST = pesticide;
AVS = acid volatile sulfide; SEM = simultaneously extracted metals; TOC = total organic carbon; DBT = Dibutyl tin;
MBT = Monobutyl tin; TBT = Tributyl tin; TTBT = Tetrabutyl tin; BT = Butyltin

2 - ICP = Inductively-coupled Plasma; MS = Mass Spectroscopy; GC = Gas Chromatography;
ECD = Electron Capture Detector.

3 - MDL = Method Detection Limit; RL = Reporting Limit.

4 - Sediments analyses conducted under Validation Study (Battelle 2001);
NOAA Status and Trends methods used (NOAA, 1998) .

5 - For SEM and AVS, RL equals MDL.

Table 3.1-1. Summary of Hazard Quotients calculated from sediment concentrations measured in the Hunter's Point TIE study[1].

Class	Analyte	Benchmark Source[2]	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)
MET	Aluminum	NA											
MET	Antimony	AET-L	-	-	-	-	-	-	-	-	-	-	-
MET	Arsenic	ER-M	-	-	-	-	-	-	-	-	-	-	-
MET	Barium	NA											
MET	Cadmium	ER-M	-	-	-	-	-	-	-	-	-	-	-
MET	Chromium	ER-M	-	-	-	+	-	-	-	-	-	-	-
MET	Cobalt	AET-L	+	+	+	+	+	+	+	+	+	+	+
MET	Copper	ER-M	+	+	-	-	-	-	-	+	-	+	-
MET	Iron	NA											
MET	Lead	ER-M	-	-	-	-	-	-	-	-	-	-	-
MET	Manganese	AET-L	+	+	+	+	+	+	+	+	+	+	+
MET	Mercury	ER-M	-	-	-	-	+	+	-	+	+	+	-
MET	Molybdenum	NA											
MET	Nickel	ER-M	+	+	+	++	+	+	+	++	+	+	+
MET	Selenium	AET-L	-	-	-	-	-	-	-	-	-	-	-
MET	Silver	ER-M	-	-	-	-	-	-	-	-	-	-	-
BT	DBT	NA											
BT	MBT	NA											
BT	TBT	AET-L	-	-	-	-	-	-	-	-	-	-	-
BT	TTBT	NA											
BT	Total Butyltins	NA											
MET	Vanadium	NA											
MET	Zinc	ER-M	-	-	-	-	-	-	-	-	-	-	-
SEM	SEM-AVS	EPA	-	-	-	-	-	-	-	-	-	-	-
PAH	2-Methylnaphthalene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Acenaphthene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Acenaphthylene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Anthracene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Benzo(a)anthracene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Benzo[a]pyrene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Benzo[b]fluoranthene	AET-H	-	-	-	-	-	-	-	-	-	-	-
PAH	Benzo[ghi]perylene	AET-H	-	-	-	-	-	-	-	-	-	-	-
PAH	Benzo[k]fluoranthene	AET-H	-	-	-	-	-	-	-	-	-	-	-
PAH	Chrysene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Dibenz[a,h]anthracene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Fluoranthene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Fluorene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Indeno[1,2,3-cd]pyrene	AET-L	-	-	-	-	-	-	-	-	-	-	-
PAH	Naphthalene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Phenanthrene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Pyrene	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Total LMW (L) PAHs	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Total HMW (H) PAHs	ER-M	-	-	-	-	-	-	-	-	-	-	-
PAH	Total PAHs	ER-M	-	-	-	-	-	-	-	-	-	-	-
PCB	Total PCBs	ER-M	++	-	-	+	++	+++	++	+++	+++	-	-
PST	2,4'-DDD	ER-M	-	-	-	-	-	-	-	-	-	-	-
PST	2,4'-DDE	ER-M	-	-	-	-	-	-	-	-	-	-	-
PST	2,4'-DDT	ER-M	-	-	-	-	-	-	-	-	-	-	-
PST	4,4'-DDD	ER-M	-	-	-	-	-	-	-	+	-	-	-
PST	4,4'-DDE	ER-M	-	-	-	-	-	-	-	-	-	-	-
PST	4,4'-DDT	ER-M	-	-	-	-	-	-	-	-	-	-	-
PST	alpha-Chlordane	PEL	-	-	-	-	-	-	-	-	-	-	-
PST	Dieldrin	PEL	-	-	-	-	-	++	-	-	-	-	-
PST	Endosulfan II	SQAL	-	-	-	-	-	-	-	-	-	-	-
PST	Endrin	SQAL	-	-	-	-	-	-	-	-	-	-	-
PST	gamma-Chlordane	PEL	-	-	-	-	-	-	-	-	-	-	-
PST	Heptachlor	AET-L	-	-	-	-	-	-	-	-	-	-	-

LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene).
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene).
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2.
1- Hazard Quotient (see Appendix A-2-1 for values) codes: <benchmark(BM) = "-"; >BM = "+"; >3xBM = "++"; >10xBM = "+++".
2- See Table 2.2-1 for benchmarks; NA = benchmark not available.

Table 3.1-2. Summary of Hazard Quotients calculated from pore water concentrations in sediments collected for the Hunter's Point TIE study[1].

Class	Analyte	Benchmark Source[2]	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)	HP-PC	HP-SPIKE
MET	Aluminum	WQC-FA	-	-	-	-	-	-	+++	++	-	+	+	-	-
MET	Arsenic	WQC-SA	-	-	+	-	-	-	-	-	-	-	-	-	-
MET	Cadmium	WQC-SA	-	-	-	-	-	-	-	-	-	-	-	-	-
MET	Chromium	WQC-SA	-	-	-	-	-	-	-	-	-	-	-	-	-
MET	Copper	WQC-SA	+	+	+	-	+	+	+++	++	+	++	+	-	+++
MET	Iron	NA													
MET	Lead	WQC-SA	-	-	-	-	-	-	-	-	-	-	-	-	-
MET	Manganese	WQC-FA	++	+	+	++	++	+	+	++	++	+	+++	-	-
MET	Nickel	WQC-SA	-	-	-	-	-	-	-	-	-	-	-	-	-
MET	Silver	WQC-SA	-	-	-	-	-	-	-	-	-	-	-	-	-
MET	Zinc	WQC-SA	-	-	-	-	-	-	+	-	-	-	-	-	-
MET	SEM-AVS	NA													
PAH	2-Methylnaphthalene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Acenaphthene	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Acenaphthylene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Anthracene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Benzo(a)anthracene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Benzo[a]pyrene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Benzo[b]fluoranthene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Benzo[ghi]perylene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Benzo[k]fluoranthene	estimated	-	-	-	-	-	-	-	-	-	-	-		
PAH	Chrysene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Dibenz[a,h]anthracene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Fluoranthene	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Fluorene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Indeno[1,2,3-cd]pyrene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Naphthalene	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Phenanthrene	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Pyrene	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Total LMW (L) PAHs	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Total HMW (H) PAHs	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PAH	Total PAHs	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PCB	Total PCBs	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PST	2,4'-DDD	estimated	-	-	-	-	-	-	-	-	-	-	-		
PST	2,4'-DDE	estimated	-	-	-	-	-	-	-	-	-	-	-		
PST	2,4'-DDT	estimated	-	-	-	-	-	-	-	-	-	-	-		
PST	4,4'-DDD	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PST	4,4'-DDE	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PST	4,4'-DDT	WQC-FA	-	-	-	-	-	-	-	-	-	-	-		
PST	alpha-Chlordane	estimated	-	-	-	-	-	-	-	-	-	-	-		
PST	Dieldrin	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PST	Endosulfan II	estimated	-	-	-	-	-	-	-	-	-	-	-		
PST	Endrin	WQC-SA	-	-	-	-	-	-	-	-	-	-	-		
PST	gamma-Chlordane	estimated	-	-	-	-	-	-	-	-	-	-	-		
PST	Heptachlor	WQC-SA	-	-	-	-	-	-	-	-	-	-	-	-	-
AMM	Un-ionized Ammonia	WQC-SA	-	-	++	++	+	-	+	++	++	++	-	-	-

LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene).
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene).
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2.
1- Hazard Quotient (see Appendix A-2-2 for values) codes: <benchmark(BM) = "-"; >BM = "+"; >3xBM = "++"; >10xBM = "+++".
2- See Table 2.2-2 for benchmarks; NA = benchmark not available.

Table 3.1-3. Species-specific Hazard Quotients for measured pore water concentrations associated with toxic TIE treatment responses observed in the Hunter's Point TIE study.

a) *S. purpuratus*

	HQs in 100% pore water			
	Copper	Zinc	Aluminum	Un-ionized Ammonia[2]
Sample ID/EC_{50} µg/L[1]	8.0	19	200	0.1
HP-1	1.0	1.1	1.4	3.2
HP-2	0.7	2.1	2.1	3.1
HP-3	0.8	1.0	2.4	37
HP-4	0.6	1.2	1.5	15
HP-5	1.4	1.0	2.4	10
HP-6	1.1	0.8	2.2	1.1
HP-7	16	11	61	5.4
HP-8	5.8	2.8	23	14
HP-9	1.2	1.3	2.8	19
HP-10	2.2	2.4	5.2	22
HP-REF	1.5	1.4	8.5	2.1
HP-PC	0.4	3.3	1.3	0.3
HP-SPIKE	39	1.0	1.3	1.5

b) *M. menidia*

	HQs in 100% pore water			
	Copper	Zinc	Manganese	Un-ionized Ammonia[2]
Sample ID/LC_{50} µg/L[1]	136	3900	3680	1.45
HP-1	0.1	5.46E-3	1.1	0.2
HP-2	0.04	0.0	0.6	0.2
HP-3	0.05	5.10E-3	0.7	2.0
HP-4	0.03	5.72E-3	1.0	0.8
HP-5	0.08	5.05E-3	1.2	0.6
HP-6	0.06	4.13E-3	0.5	0.1
HP-7	0.95	0.1	0.5	0.3
HP-8	0.34	0.0	2.3	0.8
HP-9	0.07	6.56E-3	1.5	1.0
HP-10	0.13	0.0	0.6	1.2
HP-REF	0.09	6.92E-3	3.9	0.1
HP-PC	0.03	0.02	1.63E-4	0.02
HP-SPIKE	2.3	4.69E-3	3.26E-4	0.1

c) *D. excentricus*

	HQs in 100% pore water			
	Copper	Zinc	Manganese	Unionized Ammonia[2]
Sample ID/EC_{50} µg/L[1]	20	NA	NA	NA
HP-1	0.4			
HP-2	0.3			
HP-3	0.3			
HP-4	0.2			
HP-5	0.6			
HP-6	0.4			
HP-7	6.5			
HP-8	2.3			
HP-9	0.5			
HP-10	0.9			
HP-REF	0.6			
HP-PC	0.2			
HP-SPIKE	16			

1 - median of range of literature values reported in Table 2.2-3.

2 - calculated from Total Ammonia; see Appendix A-3.

3 - calculated assuming 10% dilution of measured pore water (i.e. 100%) concentration.

Table 3.2-1. Toxicity test results from 10-day bulk sediment tests, sediment-water interface (SWI) and pore water TIE tests on samples collected at Hunter's Point[1].

Sample			Bulk Sediment Test[2, 3]	SWI Test[2]	Pore water TIE Test; 10%	Pore water TIE Test; 100%	
SAIC TIE ID	**Area**	**Station**	**%Survival** ***E. estuarius***	**%Normal** ***S. purpuratus***	**%Normal** ***S. purpuratus***	**%Normal** ***S. purpuratus***	**%Survival** ***M. menidia***
HP-1	Area III	PA-41 (0-5cm)	75	98	20	0	100
HP-2	Area III	PA-41 (5-10cm)	75		17	0	125
HP-3	Area IIX	EW-33 (0-5cm)	102	56	4	0	0
HP-4	Area IX	OR-24 (0-5cm)	96	81	35	0	58
HP-5	Area X	SB-20 (0-5cm)	93	93	52	0	8
HP-6	Area X	SB-20 (5-10cm)	72		7	0	125
HP-7	Area X	SB-18 (0-5cm)	100	92	0	0	125
HP-8	Area X	SB-21 (0-5cm)	101	98	0	0	0
HP-9	Area X	SB-22 (0-5cm)	76	95	4	0	0
HP-10	Area X	SB-23 (0-5cm)	100	90	0	0	0
HP-REF	Paradise Cove	PC-63 (0-5cm)			4	0	117
Control			100	100	100	100	100
Spike						0	0

1 - Results normalized to mean control responses.

2 - Data source: Battelle, 2001.

3 -normalized to test-specific control (not mean control).

Table 3.2-2. Summary of measured sediment and water quality parameters in samples tested for toxicity for the Hunter's Point Validation Study/TIE evaluation.

Sample			Sediment Characteristics			Bulk Sediment Test	SWI Test		TIE Pore Water	
SAIC TIE ID	Area	Station[2]	TOC (%)	Moisture Content (%)	Fines Content (%)	Total Ammonia-N; Pore Water (mg/L)[1]	Total Ammonia-N (mg/L)	Un-ionized Ammonia-N (mg/L)	Total Ammonia-N (mg/L)	Un-ionized Ammonia-N (mg/L)[3]
HP-1	Area III	PA-41 (0-5cm)	1.1	55.3	80.0	6.2	1.8	7.0E-03	3.5	0.3
HP-2	Area III	PA-41 (5-10cm)	1.1	51.7	71.7	9.3			4.3	0.3
HP-3	Area IIX	EW-33 (0-5cm)	0.89	31.8	14.4	42.4	2.6	9.5E-03	26.5	2.9
HP-4	Area IX	OR-24 (0-5cm)	1.8	39.3	53.9	20.8	1.7	1.0E-02	13.0	1.2
HP-5	Area X	SB-20 (0-5cm)	1.6	50.0	92.7	16.2	0	0	11.3	0.82
HP-6	Area X	SB-20 (5-10cm)	1.6	53.8	92.7	4.4			1.5	0.09
HP-7	Area X	SB-18 (0-5cm)	0.43	25.5	15.8	20.8	0	0	18.0	0.44
HP-8	Area X	SB-21 (0-5cm)	0.69	38.8	28.2	30.2	0.6	2.0E-03	30.0	1.1
HP-9	Area X	SB-22 (0-5cm)	1.7	55.2	87.4	16.8	0.9	3.5E-03	16.5	1.5
HP-10	Area X	SB-23 (0-5cm)	0.70	31.8	19.2	34.9	0.4	1.5E-03	30.0	1.8
HP-REF	Paradise Cove	PC-63 (0-5cm)	1.0	57.1	98.3	2.8	0	0	2.8	0.17
Control									0	0
Spike									1.3	0.024
Median of TIE samples			1.1	50.0	82.8	12.8	0	0	11.3	0.4

1 - Ammonia concentration at test start reported; concentration tended to decrease over time.

2 - See Figure 2.1-1 for station locations. Sampling depth indicated in parenthesis.

3 - Calculated using fish test water quality conditions; see Appendix A-3.

Table 3.3-1. Percent normal embryo-larval development in the purple sea urchin, *Strongylocentrotus purpuratus*, exposed to Hunter's Point TIE treatments.

	TIE Treatment Result (% normal development)[1]					
		Metals		Particulates	Organics	NH_4
Station-dilution	Untreated	STS	EDTA	Filtered	Oasis	*Ulva*
HPSPIKE - 10	**0**	**8**	**58**	**26**	**19**	55
HPSPIKE - 25	**0**	**0**	**43**	**15**	**6**	**47**
HPSPIKE - 50	**0**	**0**	**6**	**4**	**0**	**51**
HPSPIKE - 100	**0**	**0**	**0**	**1**	**0**	60
HP1 - 10	**12**	**47**	63	**57**	**33**	**50**
HP1 - 25	**0**	**23**	**30**	**27**	**12**	**43**
HP1 - 50	**0**	**0**	**0**	0	**0**	**48**
HP1 - 100	**0**	**0**	**0**	0	**0**	55
HP2 - 10	**10**	**29**	**57**	**56**	**30**	**53**
HP2 - 25	**4**	**18**	**28**	**18**	**4**	**41**
HP2 - 50	**0**	**0**	**0**	**0**	**0**	**44**
HP2 - 100	**0**	**0**	**0**	**0**	**0**	**55**
HP3 - 10	**2**	**6**	**28**	**0**	**0**	**53**
HP3 - 25	**0**	**0**	**0**	**0**	**0**	**45**
HP3 - 50	**0**	**0**	**0**	**0**	**0**	**45**
HP3 - 100	**0**	**0**	**0**	**0**	**0**	**53**
HP4 - 10	**21**	**64**	**56**	**58**	**37**	54
HP4 - 25	**0**	**13**	**14**	**6**	**6**	58
HP4 - 50	**0**	**0**	**0**	**0**	**0**	49
HP4 - 100	**0**	**0**	**0**	**0**	**0**	**28**
HP5 - 10	**31**	**68**	**32**	**59**	**24**	56
HP5 - 25	**0**	**0**	**4**	**0**	**1**	**50**
HP5 - 50	**0**	**0**	**0**	**0**	**0**	**36**
HP5 - 100	**0**	**0**	**0**	**0**	**0**	**51**
HP6 - 10	**4**	**50**	**48**	60	**37**	48
HP6 - 25	**13**	**57**	**44**	59	**32**	**36**
HP6 - 50	**3**	**33**	**31**	**22**	**21**	52
HP6 - 100	**0**	**0**	**14**	**0**	**2**	63
HP7 - 10	**0**	**39**	**36**	NP	**31**	43
HP7 - 25	**0**	**0**	**2**	NP	**2**	31
HP7 - 50	**0**	**0**	**0**	NP	**0**	29
HP7 - 100	**0**	**0**	**0**	NP	**0**	39
HP8 - 10	**0**	**0**	**1**	**0**	**0**	41
HP8 - 25	**0**	**0**	**0**	**0**	**0**	37
HP8 - 50	**0**	**0**	**0**	NP	**0**	40
HP8 - 100	**0**	**0**	**0**	NP	**0**	31
HP9 - 10	**2**	**51**	**36**	**43**	**33**	**43**
HP9 - 25	**0**	**0**	**3**	**0**	**0**	**42**
HP9 - 50	**0**	**0**	**0**	**0**	**0**	**43**
HP9 - 100	**0**	**0**	**0**	**0**	**0**	**43**
HP10 - 10	**0**	**1**	**4**	**0**	**0**	**31**
HP10 - 25	**0**	**0**	**0**	**0**	**0**	**18**
HP10 - 50	**0**	**0**	**0**	**0**	**0**	**35**
HP10 - 100	**0**	**0**	**0**	**0**	**0**	**3**
HPREF - 10	3	**44**	**35**	62	**29**	49
HPREF - 25	14	**34**	**35**	**49**	**20**	**42**
HPREF - 50	2	**9**	**2**	**6**	**4**	**37**
HPREF - 100	0	**0**	**0**	**0**	**0**	**41**
PC-100	59	78	67	66	58	67

NP = no pore water available.

1 - Shaded values indicate improvement (greater than or equal to 5%) relative to previous treatment(s). Bold values are statistically different (α=0.05) from performance control as determined by Dunnett's t-test.

Table 3.3-2. Percent survival in the fish, *Menidia menidia*, exposed to Hunter's Point TIE treatments.

	TIE Treatment Result (% Survival)[1]						
		Metals		Particulates	Organics	NH_4	NH_3
Station-dilution	Untreated	STS	EDTA	Filtered	Oasis	*Ulva*	High pH[2]
Spike - 50	100	100	100	100	100	90	100
Spike - 100	7	47	53	80	73	100	80
HP1 - 50	100	100	100	100	100	100	100
HP1 - 100	80	93	100	100	80	100	80
HP2 - 50	100	100	100	100	100	100	100
HP2 - 100	100	80	100	100	60	93	100
HP3 - 50	100	100	90	100	90	100	100
HP3 - 100	**0**	**0**	**0**	**0**	**0**	100	**0**
HP4 - 50	100	100	100	100	100	100	100
HP4 - 100	**47**	100	100	100	87	100	50
HP5 - 50	100	100	100	100	100	100	100
HP5 - 100	**7**	20	13	87	**7**	93	73
HP6 - 50	100	100	100	100	100	100	100
HP6 - 100	100	100	93	100	73	100	100
HP7 - 50	100	100	100	NP	100	100	100
HP7 - 100	NP	NP	NP	NP	NP	87	60
HP8 - 50	100	100	100	100	100	100	100
HP8 - 100	**0**	**0**	**0**	**0**	**0**	87	**0**
HP9 - 50	100	100	100	100	100	100	100
HP9 - 100	**0**	**0**	13	47	**33**	100	0
HP10 - 50	100	100	100	100	100	100	100
HP10 - 100	**0**	**0**	**0**	**0**	**0**	100	100
HPREF - 50	100	100	100	90	100	100	100
HPREF - 100	93	93	93	100	87	100	100
PC-100	80	73	60	60	67	93	87

NP = no pore water available.

1 - Shaded values indicate improvement (greater than or equal to 5%) relative to previous treatment(s). Bold values are statistically different (α=0.05) from performance control as determined by Dunnett's t-test.

2 - Decreased survival associated with the High pH treatment is consistent with the shift to a larger proportion of the more toxic unionized form of ammonia.

Table 3.3-3. Percent normal embryo-larval development in the sand dollar, *Dendraster excentricus*, exposed to Hunter's Point TIE treatments.

	TIE Treatment Result (% normal development)[1]									
		Metals		Particulates	Organics	NH_4	NH_3	NH_4	Metals	Metals
Station-dilution	Untreated	STS	EDTA	Filtered	Oasis	*Ulva*	High pH[2]	*Ulva* 1st *Ulva*[3]	*Ulva* 1st STS[3]	*Ulva* 1st EDTA[3]
HP4 - 1	95	96	95	95	91	89	92	91	94	94
HP4 - 10	96	94	95	93	84	91	90	95	93	91
HP4 - 50	**1**	**0**	**0**	**0**	**0**	82	**0**	91	92	94
HP4 - 100	**1**	**0**	**0**	**0**	**0**	82	**0**	**49**	**66**	**75**
HP5 - 1	96	94	98	91	85	88	89	95	91	94
HP5 - 10	**32**	**33**	**60**	**65**	**38**	84	**41**	93	96	95
HP5 - 50	**0**	**0**	**0**	**0**	**0**	67	**1**	**1**	**14**	**5**
HP5 - 100	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
HP9 - 1	95	92	95	92	87	89	93	88	96	91
HP9 - 10	**7**	**14**	**30**	**54**	**18**	75	**83**	84	93	95
HP9 - 50	**0**	**0**	**0**	**0**	**0**	69	**0**	**51**	90	96
HP9 - 100	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**5**
HPREF - 1	95	95	94	93	92	86	90	91	94	91
HPREF - 10	94	94	95	94	95	84	87	89	92	88
HPREF - 50	**30**	**33**	**77**	**69**	**60**	81	**62**	**84**	82	**79**
HPREF - 100	**0**	**2**	**0**	**0**	**1**	**49**	**0**	**61**	**72**	**80**
PC-100	96	93	93	90	92	60	94	92	90	95

1 - Shaded values indicate improvement (greater than or equal to 5%) relative to previous treatment(s). Bold values are statistically different (α=0.05) from performance control as determined by Dunnett's t-test.

2 - Decreased survival associated with the High pH treatment is consistent with the shift to a larger proportion of the more toxic unionized form of ammonia.

3 - In a second round of manipulations, the order of select treatments was reversed to reduce masking effect of ammonia.

Table 3.3-4. Summary of toxicity removed by TIE treatment for the purple sea urchin, *Strongylocentrotus purpuratus*, exposed to Hunters Point TIE sediment pore waters.

Station	Total Toxicity Removed by TIE[1]	Reduction in Toxicity due to each TIE Treatment (as % of total effects observed in untreated sample)[2]				Treatments that Removed Toxicity, in order of Relative Effectiveness[3]
		STS	EDTA	Filtraton	*Ulva*	
HP-SPIKE	79	4	46	0	51	*Ulva* = EDTA
HP-1	72	29	11	0	63	*Ulva* >*S* TS>EDTA
HP-2	70	17	19	0	63	*Ulva* >EDTA=STS
HP-3	73	2	10	0	87	*Ulva* >EDTA
HP-4	68	29	1	0	72	*Ulva* >STS
HP-5	68	20	2	0	82	*Ulva* >STS
HP-6	72	62	7	6	38	STS>*Ulva* >EDTA=Filtration
HP-7	53	18	1	0	71	*Ulva* >STS
HP-8	56	0	0	0	99	*Ulva*
HP-9	64	23	1	0	74	*Ulva* >STS
HP-10	32	0	1	0	95	*Ulva*
HP-REF	60	35	1	16	44	*Ulva* = STS>Filtration

[1] % of Normal development that was restored by the cumulative TIE treatment in all 4 dilutions as a % of the *Ulva* control response (67%).

[2] % of Normal development that was restored by each individual TIE treatment in all 4 dilutions, expressed as a percent of the total toxicity removed (e.g. for HP-spike, 4% of the 79% overall improvement was due to STS treatment).
Zero values are reported when no reduction in effect was observed relative to previous treatment.
Oasis SPE is not included because no reductions in toxicity were associated with this treatment.

[3] ">" = 10% or higher difference in toxicity reduction; treatments resulting in <5% reduction not listed.

Table 3.3-5. Summary of toxicity removed by TIE treatment for the fish, *Menidia menidia*, exposed to Hunter's Point TIE sediment pore waters.

Station	Total Toxicity Removed by TIE[1]	Reduction in Toxicity due to each TIE Treatment (as % of total effects observed in untreated sample)[2]				Treatments that Removed Toxicity, in order of Relative Effectiveness[3]
		STS	EDTA	Filtraton	*Ulva*	
HP-SPIKE[a]	100	43	6	29	21	STS>Filtration=*Ulva*> EDTA
HP-1[a]	100	65	35	0	0	STS>EDTA
HP-2	NT					No toxicity observed in untreated sample
HP-3[a, b]	100	0	0	0	100	*Ulva*
HP-4[a]	100	100	0	0	0	STS
HP-5[a]	92	15	0	78	7	Filtration>STS=*Ulva*
HP-6	NT					No toxicity observed in untreated sample
HP-7	NT					No toxicity observed in untreated sample
HP-8[a, b]	87	0	0	0	100	*Ulva*
HP-9[a]	100	0	13	34	53	*Ulva*> Filtraton>EDTA
HP-10[a, b]	100	0	0	0	100	*Ulva*
HP-REF[a]	NT					No toxicity observed in untreated sample

[a] Toxicity observed in 100% dilution only.

[b] Low DO alone would have resulted in complete mortality.

[1] % of Normal development that was restored by the cumulative TIE treatment in all 4 dilutions as a % of the treatment control response.

[2] % of Normal development that was restored by each individual TIE treatment in all 4 dilutions, expressed as a percent of the total toxicity removed, (e.g. for HP-spike, 43% of the 100% overall improvement was due to STS treatment).
Zero values are reported when no reduction in effect was observed relative to previous treatment.
Oasis SPE is not included because no reductions in toxicity were associated with this treatment.
NT= Not toxic.

[3] ">" = 10% or higher difference in toxicity reduction; treatments resulting in <5% reduction not listed.

Table 3.3-6. Summary of toxicity removed by TIE treatment for the sand dollar, *Dendraster excentricus*, exposed to Hunter's Point TIE sediment pore waters.

Series I (Normal TIE)

Station	Total Toxicity Removed by TIE[1]	Reduction in Toxicity due to each TIE Treatment (as % of total effects observed in untreated sample)[2]				Treatments that Removed Toxicity, in order of Relative Effectiveness[3]
		STS	EDTA	Filtraton	*Ulva*	
HP-4	88	1	0	0	100	*Ulva*
HP-5	48	1	24	4	72	*Ulva* >EDTA>Filtration
HP-9	50	5	12	18	66	*Ulva* >Filtration=EDTA
HP-REF	64	5	45	0	51	*Ulva* = EDTA>STS

Series II (*Ulva* first)

Station	Total Toxicity Removed by TIE[1]	Reduction in Toxicity due to each TIE Treatment (as % of total effects observed in untreated sample)[2]			Treatments that Removed Toxicity, in order of Relative Effectiveness[3]
		Ulva	STS	EDTA	
HP-4	91	83	11	7	*Ulva* >STS>EDTA
HP-5	31	81	21	0	*Ulva* >STS
HP-9	70	68	28	5	*Ulva* >STS>EDTA
HP-REF	86	86	8	6	*Ulva* >STS=EDTA

[1] % of Normal development that was restored by the cumulative TIE treatment in all 4 dilutions as a % of the mean control response across treatments (90%).
Note: The sum of % changes deviates from 100% in some cases (e.g. *Ulva* 1st, HP-5) where treatment control exceeded mean control response.

[2] % of Normal development that was restored by each individual TIE treatment in all 4 dilutions, expressed as a percent of the total toxicity removed.
Zero values are reported when no reduction in effect was observed relative to previous treatment.
Oasis SPE is not included because no reductions in toxicity were associated with this treatment.

[3] ">" = 10% or higher difference in toxicity reduction; treatments resulting in <5% reduction not listed.

Table 4.1-1. Summary of findings from the Hunter's Point TIE investigation.

Area	SAIC TIE ID	Treatment(s) that Reduced Pore Water Toxicity and Associated Probable Toxicant(s)[1]			Potential Toxicants Identified in Porewater and Sediment HQs
		Fish	Urchin	Sand Dollar	
Point Avisadero	HP-1	STS>EDTA- Manganese, Copper	*Ulva* -NH_4> STS>EDTA- metals	ND	Sed. HQs: Cobalt (1.7), Copper (1.9), Manganese (1.9), Nickel (2.3), Total PCBs (3.9) PW HQs: Copper (1.7), Manganese (4.1)
Point Avisadero	HP-2	NT	*Ulva* -NH_4> EDTA=STS- metals	ND	Sed. HQs: Cobalt (1.8), Copper (1.0), Manganese (1.8), Nickel (2.1) PW HQs: Copper (1.1), Manganese (2.3)
Eastern Wetland	HP-3	Low DO>*Ulva* - NH_4	*Ulva* -NH_4> EDTA- metals	ND	Sed. HQs: Cobalt (1.3), Manganese (2.2), Nickel (1.2) PW HQs: Arsenic (1.1), Copper (1.4), Manganese (2.5), Un-ionized ammonia (9.3)
Oil Reclamation	HP-4	STS- Aluminum, Zinc, Copper	*Ulva* -NH_4> STS- metals	*Ulva* -NH_4 *Ulva* -NH_4>STS>EDTA-Aluminum, Zinc, Copper[2]	Sed. HQs: Chromium (1.2), Cobalt (2.0), Manganese (2.4), Nickel (3.1), Total PCBs (2.4) PW HQs: Manganese (3.6), Un-ionized ammonia (3.7)
South Basin	HP-5	Filtered-particle fraction> STS-Manganese, Copper= *Ulva* -NH_4	*Ulva*- NH_4> STS- metals	*Ulva* -NH_4> EDTA>Filtration *Ulva* -NH_4>STS-Aluminum, Copper, Zinc[2]	Sed. HQs: Cobalt (1.7), Manganese (1.7), Mercury (1.3), Nickel (2.3), Total PCBs (8.7) PW HQs: Copper (2.4), Manganese (4.6), Un-ionized ammonia (2.6)
South Basin	HP-6	NT	STS- metals> *Ulva* -NH_4>EDTA- metals =Filtration- particle fraction	ND	Sed. HQs: Cobalt (1.8), Manganese (1.6), Mercury (1.2), Nickel (2.5), Dieldrin (4.7), Total PCBs (11) PW HQs: Copper (1.8), Manganese (1.9)
South Basin	HP-7	NT	*Ulva* -NH_4> STS- Aluminum, Copper, Zinc	ND	Sed. HQs: Cobalt (1.1), Manganese (1.4), Nickel (1.8), Total PCBs (4.6) PW HQs: Aluminum (16), Copper (27), Manganese (1.7), Zinc (2.4), Un-ionized ammonia (1.4)
South Basin	HP-8	Low DO>*Ulva* -NH_4	*Ulva* -NH_4	ND	Sed. HQs: Cobalt (2.2), Copper (1.2), Manganese (1.7), Mercury (2.1), Nickel (3.1), Total PCBs (29), 4,4'-DDD (1.6) PW HQs: Aluminum (6.2), Copper (9.7), Manganese (8.4), Un-ionized ammonia (3.5)
South Basin	HP-9	*Ulva* -NH_4> Filtered-particle fraction> EDTA- Manganese, Copper	*Ulva* -NH_4> STS- metals	*Ulva* -NH_4>Filtration-particle fraction=EDTA>STS- Aluminum, Zinc, Copper *Ulva* -NH_4>STS>EDTA-Aluminum, Zinc, Copper[2]	Sed. HQs: Cobalt (1.8), Manganese (1.7), Mercury (1.8), Nickel (2.5), Total PCBs (10) PW HQs: Copper (2.0), Manganese (5.6), Un-ionized ammonia (4.7)
South Basin	HP-10	Low DO>*Ulva* -NH_4	*Ulva* -NH_4	ND	Sed. HQs: Cobalt (1.0), Copper (1.0), Manganese (1.2), Mercury (1.2), Nickel (2.4) PW HQs: Aluminum (1.4), Copper (3.7), Manganese (2.0), Un-ionized ammnia (5.5)
Paradise Cove	HP-REF	NT	*Ulva* -NH_4=STS-Aluminum, Copper, Zinc>Filtration-particle fraction	*Ulva* -NH_4=EDTA>STS-Aluminum, Copper, Zinc *Ulva* -NH_4=STS>EDTA-Aluminum, Copper, Zinc[2]	Sed. HQs: Cobalt (1.7), Manganese (2.1), Nickel (1.7) PW HQs: Aluminum (2.3), Copper (2.4), Manganese (14)

1 - in order of percent of overall toxicity removed (Table 3.3-4, 3.3-5 and 3.3-6); see text for probable CoCs.

2 - observed in reverse treatment

NT = not toxic; ND = no data

Appendix A-1-1. Measured sediment concentrations of chemicals for the Hunter's Point TIE study[1].

Class	Analyte	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)
MET	Aluminum	66500	67700	43500	57300	70050	70100	49200	46400	65300	47900	72100
MET	Antimony	1.09	2.64	3.64	2.38 J	5.48 J	4.96 J	3.95	0.65	7.43 J	7.26	0.77
MET	Arsenic	11	12	6.12	11 J	12 J	12 J	5.86	9.95	13 J	7.03	12
MET	Barium	568	501	372	381	481	489	458	761	459	726	472
MET	Cadmium	0.33 J	0.33 J	0.26 J	0.34 J	0.65	0.84	0.43 J	0.26 J	0.57 J	0.40 J	0.19 J
MET	Chromium	349	303	225	434	240	270	175	338	256	292	161
MET	Cobalt	17	18	13	20	17	18	11	22	18	11	17
MET	Copper	525 J	279 J	21	98	133	164	66 J	319 J	163	277 J	40 J
MET	Iron	42500	41800	27200	45600	45600	44800	25500	31000	42600	21000	41200
MET	Lead	109 J	105 J	19	60	110	133	122 J	12 J	142	114 J	22 J
MET	Manganese	494	463	579	624	451	421	357	453	446	305	554
MET	Mercury	0.48	0.53	0.14 J	0.48 J	0.91	0.84 J	0.23 J	1.47 J	1.26 J	0.84 J	0.29
MET	Molybdenum	1.12	1.75	0.49	1.41 J	1.10	1.58 J	0.70	0.77	1.50 J	0.83	0.82
MET	Nickel	119 J	108 J	60	160	121	128	93	161	130	123	87 J
MET	Selenium	0.51 J	0.44 J	0.06 U	0.24 J	0.39 J	0.41 J	0.15 J	0.18 J	0.36 J	0.20 J	0.29 J
MET	Silver	0.29	0.33	0.07 J	0.36 J	0.64 J	0.73 J	0.26 J	0.14 J	0.70 J	0.37 J	0.24
BT	DBT	0.06	0.13	6.2E-4 U	0.02	0.02	0.02	0.01	0.03	0.04	0.05	1.0E-3 U
BT	MBT	5.0E-4 UJ	5.0E-4 UJ	3.3E-4 UJ	2.7E-3 J	5.7E-4 UJ	5.2E-4 UJ	3.3E-4 UJ	3.7E-4 UJ	5.3E-4 UJ	3.5E-4 U	5.4E-4 UJ
BT	TBT	0.21 D	0.38 D	4.4E-4 U	0.07	0.03	0.02	0.02	0.06	0.06	0.13 D	7.2E-4 U
BT	TTBT	1.2E-3 U	1.2E-3 U	7.8E-4 U	1.1E-3 U	1.3E-3 U	1.2E-3 U	7.7E-4 U	8.8E-4 U	1.3E-3 U	8.2E-4 U	1.3E-3 U
BT	Total Butyltins	0.26	0.51		0.09	0.05	0.04	0.03	0.09	0.09	0.18	
MET	Vanadium	128	133	83	134	138	144	78	172	141	51	139
MET	Zinc	207	170	80	179	246	267	209 J	297 J	243	212 J	105
MET	SEM-AVS	1.24	-2.50	-6.14	-9.31	-3.39	-11.03	-5.83	1.27	-7.60	-3.54	0.40
PAH	2-Methylnaphthalene	20 B	15 B	1.59	9.85	20	40	21	27	24	19	3.88
PAH	Acenaphthene	182	42	1.63	7.62	7.70	12	11	21	6.97	12	2.51
PAH	Acenaphthylene	18	18	1.09	10	11	14	13	31	12	44	5.00
PAH	Anthracene	143	102	4.87	61	43	60	51	234	35	187	16
PAH	Benzo(a)anthracene	601	350	13	151	186	184	293	629	199	393	46
PAH	Benzo[a]pyrene	706	449	22	202	297	323	315	632	343	434	97
PAH	Benzo[b]fluoranthene	550	355	14	149	239	242	277	484	254	304	62
PAH	Benzo[ghi]perylene	481 B	332 B	21	170	296	327	194	384	319	283	88
PAH	Benzo[k]fluoranthene	546	361	16	169	248	253	290	500	260	346	61
PAH	Chrysene	715	394	17	262	276	255	453	744	269	551	65
PAH	Dibenz[a,h]anthracene	95 J	63 J	1.64	25	36	42	52 J	104 J	46	65 J	8.09
PAH	Fluoranthene	1214	683	38	291	406	346	466	953	320	650	118
PAH	Fluorene	92	53	1.55	11	12	21	16	81	11	49	4.11
PAH	Indeno[1,2,3-cd]pyrene	506	347	17	148 J	243	278	206	413	281	293	80
PAH	Naphthalene	18 B	25 B	1.76 U	15 B	40	60	57	41	42	25	8.34
PAH	Phenanthrene	751 B	375 B	19	135	147	147	153	668	104	469	51
PAH	Pyrene	1339 B	766 B	46	328	466	437	518	1065	406	749	152
PAH	Total LMW (L) PAHs	1225	631	33	250	281	354	323	1104	234	805	91
PAH	Total HMW (H) PAHs	4670	2705	138	1259	1666	1587	2096	4126	1583	2843	486
PAH	Total PAHs	5895	3336	171	1509	1947	1941	2419	5230	1817	3647	576
PCB	PCB 101	20 J	7.17	0.51 J	13 J	42 D	76 J	26 D	125 J	55 J	0.04 U	0.12 J
PCB	PCB 105	0.05 U	1.40	0.11 J	1.08 J	6.01	17 J	2.57	14 J	5.30 J	0.03 U	0.05 UJ
PCB	PCB 110	8.24 J	4.46 J	0.60 J	6.75 J	30 J	68 J	17 J	66 J	38 J	0.04 U	0.16 J
PCB	PCB 118	6.39	2.75	0.31 J	4.60 J	24 D	48 J	11	34 J	25 J	0.04 U	0.11 J
PCB	PCB 126	0.07 U	0.07 U	0.05 U	0.07 UJ	0.08 U	0.08 UJ	0.05 U	0.05 UJ	0.07 UJ	0.05 U	0.08 UJ
PCB	PCB 128	4.86	0.86 J	0.22 J	2.61 J	9.83	18 J	5.96	29 J	14 J	0.06 U	0.10 UJ
PCB	PCB 129	0.04 U	0.04 U	0.03 U	0.04 UJ	0.05 U	0.04 UJ	0.03 U	0.03 UJ	0.04 UJ	0.03 U	0.05 UJ
PCB	PCB 138	60 J	6.18	1.77	35 J	129 D	157 J	76 D	442 J	160 J	0.03 U	0.19 J
PCB	PCB 153	89 J	11	2.58	59 J	185 D	213 J	105 D	638 J	217 J	0.05 U	0.25 J
PCB	PCB 170	41 J	3.19	0.81	18 J	78 D	86 J	38 D	292 J	89 J	0.03 U	0.36 J
PCB	PCB 18	0.74 J	0.50 J	0.03 U	0.09 J	0.46 J	0.86 J	0.35 J	0.30 J	0.41 J	0.03 U	0.04 UJ
PCB	PCB 180	72 J	5.35	1.65	43 J	151 D	162 J	74 D	569 J	172 J	0.04 U	0.19 J
PCB	PCB 187	35 J	3.35	1.06	23 J	86 D	86 J	40 D	288 J	92 J	0.03 U	0.09 J
PCB	PCB 195	5.02 J	0.56 J	0.18 J	2.70 J	17 J	18 J	6.04 J	60 J	18 J	0.03 UJ	0.02 J
PCB	PCB 206	1.48	0.47 J	0.18 J	1.01 J	9.10 J	7.48 J	2.86 J	23 J	7.81 J	0.03 U	0.05 UJ
PCB	PCB 209	0.05 U	0.05 U	0.16 J	0.27 J	1.69 J	1.44 J	1.26 J	2.75 J	1.98 J	0.03 UJ	0.05 UJ
PCB	PCB 28	1.16	0.92	0.04 U	0.29 J	1.05	1.46 J	0.73	0.57 J	0.82 J	0.04 U	0.06 UJ
PCB	PCB 44	1.64 J	1.84 J	0.03 U	0.80 J	2.59	15 J	2.30	1.85 J	2.58 J	0.03 U	0.06 UJ
PCB	PCB 52	4.00	4.50	0.13 J	1.97 J	7.74	31 J	5.22	7.70 J	7.22 J	0.04 U	0.06 UJ
PCB	PCB 66	0.06 U	0.06 U	0.04 U	0.06 UJ	2.45	4.71 J	1.45	1.24 J	2.29 J	0.04 U	0.06 UJ
PCB	PCB 77	0.08 U	0.08 U	0.06 U	0.08 UJ	0.09 U	0.09 UJ	0.06 U	0.06 UJ	0.09 UJ	0.06 U	0.09 UJ
PCB	PCB 8	1.07 J	0.08 UJ	0.05 UJ	0.08 UJ	0.55 J	0.93 J	0.48 J	0.06 UJ	0.44 J	0.05 UJ	0.09 UJ
PCB	Total PCBs	705	110	22	426	1565	2026	831	5186	1818	3.18	6.18

Appendix A-1-1. continued.

Class	Analyte	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)
PST	2,4'-DDD	0.05 U	0.05 U	0.04 U	0.05 UJ	0.06 U	0.06 UJ	0.04 U	0.04 UJ	0.06 UJ	0.04 U	0.06 UJ
PST	2,4'-DDE	0.07 U	0.07 U	0.04 U	0.06 UJ	0.08 U	0.07 UJ	0.04 U	0.05 UJ	0.07 UJ	0.04 U	0.07 UJ
PST	2,4'-DDT	0.06 UJ	0.06 UJ	0.04 U	0.06 UJ	0.07 U	0.07 UJ	0.04 U	0.05 UJ	0.06 UJ	0.04 U	0.07 UJ
PST	4,4'-DDD	1.74	1.71	0.27 J	3.08 J	5.38	6.76 J	4.05	44 J	5.11 J	0.03 U	0.43 J
PST	4,4'-DDE	1.48	0.82 J	0.31 J	0.33 J	9.52	12 J	6.51	5.55 J	4.29 J	0.03 U	0.33 J
PST	4,4'-DDT	0.64 J	1.06	0.03 UJ	0.78 J	0.93 J	0.69 J	0.03 UJ	3.60 J	0.78 J	0.03 UJ	0.05 UJ
PST	alpha-Chlordane	0.19 J	0.19 J	0.03 U	0.41 J	2.37	1.85 J	0.70	0.70 J	1.38 J	0.03 U	0.02 J
PST	Dieldrin	0.05 U	0.05 U	0.03 U	0.44 J	3.63	20 J	1.25	0.04 UJ	2.75 J	0.03 U	0.05 UJ
PST	Endosulfan II	0.05 U	0.05 U	0.03 U	0.05 UJ	0.06 U	0.05 UJ	0.03 U	0.04 UJ	0.05 UJ	0.03 U	0.05 UJ
PST	Endrin	0.05 U	0.05 U	0.03 U	0.04 UJ	0.05 U	0.05 UJ	0.03 U	0.03 UJ	0.05 UJ	0.03 U	0.05 UJ
PST	gamma-Chlordane	0.04 U	0.04 U	0.03 U	0.41 J	3.60	3.54 J	2.01	0.86 J	2.35 J	0.03 U	0.04 UJ
PST	Heptachlor	0.04 U	0.04 U	0.03 U	0.04 UJ	0.05 U	0.04 UJ	0.03 U	0.03 UJ	0.04 UJ	0.03 U	0.05 UJ
TOC	TOC(%)	1.08	1.14	0.89	1.75	1.63	1.64	0.43	0.69	1.70	0.70	0.97

1 - Data source: Battelle, 2001.
Units: metals = µg/g; PCBs, Pesticides (PST), PAHs = ng/g; SEM-AVS= µM/g.
LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene)
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene)
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2
Data Qualifiers: "U"= not detected as at/above limit (half Method Detection Limit (MDL) reported), "J"=estimated value,
"D"=dilution- initial run outside instrument range, "B"=analyte found in both sample and associated blank.
SEM-AVS = Sum SEM ([Cu]+[Cd]+[Pb]+[Ni]+[Zn]) - AVS; Appendix A-1-2.

Appendix A-1-2. Measured concentrations of simultaneously extracted metals (SEM) and acid volatile sulfides (AVS) in sediments collected for the Hunter's Point TIE investigation.

CLASS	ANALYTE	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)
SEM	Cadmium	2.3E-3	2.5E-3	1.8E-3	2.1E-3	3.0E-3	3.7E-3	3.2E-3	2.6E-3	4.2E-3	2.2E-3	2.0E-3
SEM	Copper	1.20	0.90	0.19	0.43	0.61	0.76	0.35	1.70	0.88	0.93	0.23
SEM	Lead	0.10	0.09	0.09	0.11	0.23	0.29	0.34	0.27	0.29	0.14	0.06
SEM	Nickel	0.24	0.25	0.14	0.27	0.27	0.32	0.18	0.30	0.43	0.19	0.18
SEM	Zinc	1.10	0.96	0.54	0.78	1.20	1.40	1.30	2.20	1.60	1.30	0.47
SEM	Sum SEM	2.64	2.20	0.96	1.59	2.31	2.77	2.17	4.47	3.20	2.56	0.94
AVS	Acid Volatile Sulfide	1.40	4.70	7.10	11	5.70	14	8.00	3.20	11	6.10	0.27 U
SEM	SEM-AVS	1.24	-2.50	-6.14	-9.31	-3.39	-11.0	-5.83	1.27	-7.60	-3.54	0.40

units = µM/g dry wt

Data Qualifiers: "U"=Undetected (half Method Detection Limit (MDL)) reported.

Sum SEM = [Cu]+[Cd]+[Pb]+[Ni]+[Zn].

Appendix A-1-3. Measured pore water concentrations of metals for the Hunter's Point TIE study.

Class	Analyte	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)	HP-PC	HP-SPIKE
MET	Aluminum	289	426	479	304	480	434	12200	4630	558	1040	1690	255	257
MET	Arsenic	38	39	73	33	49	15	52	29	41	28	18	0.85 U	0.85 U
MET	Cadmium	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U	0.27 U
MET	Chromium	4.50 B	4.80 B	4.60 B	4.80 B	7.30 B	7.00 B	90	23	6.40 B	8.40 B	7.80 B	3.40 B	3.60 B
MET	Copper	8.20 B	5.30 B	6.50 B	4.50 B	11	8.70 B	129	47	9.80 B	18	12	3.40 B	315
MET	Iron	16500	9960	11200	10800	19200	9070	18700	5740	11600	11000	2450	110	92 B
MET	Lead	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U	86	19	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U
MET	Manganese	4120	2320	2450	3590	4590	1860	1670	8350	5570	2040	14400	0.60 U	0.60 U
MET	Nickel	8.50 B	6.40 B	8.80 B	5.20 B	7.10 B	5.00 B	56	20	5.40 B	11	13	1.20 U	1.20 U
MET	Silver	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U
MET	Zinc	21	40	20 B	22	20 B	16 B	216	54	26	46	27	63	18 B
AMM	Un-ionized Ammonia	0.19	0.18	2.17	0.86	0.60	0.06	0.32	0.82	1.09	1.29	0.12	0.02	0.09

Units MET = µg/L; AMM = mg/L.

Un-ionized Ammonia from urchin (*Strongylocentrotus purpuratus*) test reported as urchin is most sensitive to ammonia of species tested; calculated from measured Total Ammonia (Appendix A-3).

Data Qualifiers: "U"=Undetected (half Method Detection Limit (MDL) reported, "J"=Estimated, "B"=<reporting limit but >MDL.

Appendix A-1-4. Predicted pore water concentrations of organics for the Hunter's Point TIE investigation[1].

Class	Analyte	Koc	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)	HP-PC	HP-SPIKE
PAH	2-Methylnaphthalene	8.0E+03	0.24	0.17	0.02	0.07	0.16	0.30	0.60	0.49	0.18	0.34	0.05		
PAH	Acenaphthene	7.1E+03	2.36	0.52	0.03	0.06	0.07	0.10	0.37	0.43	0.06	0.23	0.04		
PAH	Acenaphthylene	9.6E+03	0.17	0.17	0.01	0.06	0.07	0.09	0.31	0.47	0.08	0.66	0.05		
PAH	Anthracene	3.0E+04	0.44	0.30	0.02	0.12	0.09	0.12	0.40	1.14	0.07	0.90	0.05		
PAH	Benzo(a)anthracene	4.0E+05	0.14	0.08	3.6E-3	0.02	0.03	0.03	0.17	0.23	0.03	0.14	0.01		
PAH	Benzo[a]pyrene	1.0E+06	0.06	0.04	2.4E-3	0.01	0.02	0.02	0.07	0.09	0.02	0.06	9.8E-3		
PAH	Benzo[b]fluoranthene	1.2E+06	0.04	0.03	1.2E-3	6.9E-3	0.01	0.01	0.05	0.06	0.01	0.04	5.1E-3		
PAH	Benzo[ghi]perylene	3.9E+06	0.01	7.6E-3	6.1E-4	2.5E-3	4.7E-3	5.2E-3	0.01	0.01	4.9E-3	0.01	2.3E-3		
PAH	Benzo[k]fluoranthene	1.2E+06	0.04	0.03	1.4E-3	7.8E-3	0.01	0.01	0.05	0.06	0.01	0.04	5.0E-3		
PAH	Chrysene	4.0E+05	0.17	0.09	4.8E-3	0.04	0.04	0.04	0.26	0.27	0.04	0.20	0.02		
PAH	Dibenz[a,h]anthracene	3.8E+06	2.3E-3	1.5E-3	4.9E-5	3.8E-4	5.8E-4	6.8E-4	3.2E-3	4.0E-3	7.1E-4	2.5E-3	2.2E-4		
PAH	Fluoranthene	1.1E+05	1.04	0.56	0.04	0.15	0.23	0.20	0.99	1.28	0.17	0.87	0.11		
PAH	Fluorene	1.4E+04	0.62	0.34	0.01	0.05	0.05	0.09	0.27	0.86	0.05	0.51	0.03		
PAH	Indeno[1,2,3-cd]pyrene	3.4E+06	0.01	8.9E-3	5.6E-4	2.5E-3	4.3E-3	4.9E-3	0.01	0.02	4.8E-3	0.01	2.4E-3		
PAH	Naphthalene	2.0E+03	0.84	1.10	0.10	0.43	1.23	1.81	6.55	2.95	1.24	1.80	0.43		
PAH	Phenanthrene	3.0E+04	2.34	1.11	0.07	0.26	0.30	0.30	1.19	3.26	0.21	2.27	0.18		
PAH	Pyrene	1.1E+05	1.17	0.64	0.05	0.18	0.27	0.25	1.13	1.46	0.23	1.02	0.15		
PAH	Total LMW (L) PAHs	NA	7.02	3.70	0.26	1.04	1.97	2.83	9.69	9.61	1.87	6.72	0.83		
PAH	Total HMW (H) PAHs	NA	2.59	1.40	0.10	0.40	0.59	0.53	2.63	3.34	0.49	2.29	0.30		
PAH	Total PAHs	7.6E+04	9.60	5.11	0.36	1.44	2.56	3.36	12	13	2.36	9.00	1.12		
PCB	Total PCBs	2.7E+06	0.02	3.6E-3	9.1E-4	9.1E-3	0.04	0.05	0.07	0.28	0.04	1.7E-4	2.4E-4		
PST	2,4'-DDD	9.9E+05	4.7E-6	4.4E-6	3.9E-6	2.6E-6	3.7E-6	3.4E-6	8.1E-6	5.9E-6	3.3E-6	5.1E-6	5.7E-6		
PST	2,4'-DDE	4.4E+06	1.4E-6	1.3E-6	1.0E-6	7.8E-7	1.0E-6	9.0E-7	2.1E-6	1.6E-6	8.7E-7	1.3E-6	1.6E-6		
PST	2,4'-DDT	4.4E+06	1.3E-6	1.2E-6	1.0E-6	7.1E-7	9.7E-7	9.0E-7	2.1E-6	1.5E-6	8.0E-7	1.3E-6	1.5E-6		
PST	4,4'-DDD	9.9E+05	1.6E-4	1.5E-4	3.0E-5	1.8E-4	3.3E-4	4.2E-4	9.4E-4	6.4E-3	3.0E-4	4.3E-6	4.4E-5		
PST	4,4'-DDE	4.4E+06	3.1E-5	1.6E-5	7.8E-6	4.3E-6	1.3E-4	1.7E-4	3.4E-4	1.8E-4	5.7E-5	9.8E-7	7.7E-6		
PST	4,4'-DDT	4.4E+06	1.3E-5	2.1E-5	7.6E-7	1.0E-5	1.3E-5	9.5E-6	1.6E-6	1.2E-4	1.0E-5	9.8E-7	1.2E-6		
PST	alpha-Chlordane	2.5E+06	7.2E-6	6.8E-6	1.1E-6	9.5E-6	5.9E-5	4.6E-5	6.6E-5	4.1E-5	3.3E-5	1.5E-6	8.4E-7		
PST	Dieldrin	1.9E+05	2.4E-5	2.1E-5	1.8E-5	1.3E-4	1.2E-3	6.5E-3	1.5E-3	2.7E-5	8.5E-4	2.3E-5	2.7E-5		
PST	Endosulfan II	1.1E+04	4.3E-4	4.1E-4	3.1E-4	2.4E-4	3.1E-4	2.8E-4	6.4E-4	4.7E-4	2.7E-4	4.0E-4	4.8E-4		
PST	Endrin	9.4E+04	4.4E-5	4.2E-5	3.6E-5	2.4E-5	3.3E-5	2.9E-5	7.3E-5	4.6E-5	2.8E-5	4.6E-5	4.9E-5		
PST	gamma-Chlordane	1.6E+06	2.3E-6	2.2E-6	1.7E-6	1.4E-5	1.4E-4	1.3E-4	2.8E-4	7.6E-5	8.5E-5	2.2E-6	2.5E-6		
PST	Heptachlor	2.5E+06	1.5E-6	1.4E-6	1.1E-6	8.2E-7	1.1E-6	9.9E-7	2.3E-6	1.8E-6	9.6E-7	1.5E-6	1.9E-6	1.7E-6	1.9E-6

1- Predicted concentration = sediment conc. (Appendix A-1-1)/(Koc *%TOC (Appendix A-1-1)*0.01).
units = µg/L
LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene)
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene)
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2

Appendix A-2-1. Hazard Quotients for chemicals in sediment collected for the Hunter's Point TIE investigation.

Class	Analyte	Benchmark	Benchmark Source	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)
MET	Aluminum	NA	NA											
MET	Antimony	9.3	AET-L	0.12	0.28	0.39	0.26	0.59	0.53	0.42	0.07	0.80	0.78	0.08
MET	Arsenic	70	ER-M	0.16	0.17	0.09	0.16	0.16	0.18	0.08	0.14	0.18	0.10	0.16
MET	Barium	NA	NA											
MET	Cadmium	9.6	ER-M	0.03	0.03	0.03	0.04	0.07	0.09	0.04	0.03	0.06	0.04	0.02
MET	Chromium	370	ER-M	0.94	0.82	0.61	1.17	0.65	0.73	0.47	0.91	0.69	0.79	0.44
MET	Cobalt	10	AET-L	1.65	1.83	1.28	1.98	1.73	1.76	1.13	2.19	1.82	1.05	1.72
MET	Copper	270	ER-M	1.94	1.03	0.08	0.36	0.49	0.61	0.24	1.18	0.60	1.03	0.15
MET	Iron	NA	NA											
MET	Lead	218	ER-M	0.50	0.48	0.08	0.28	0.50	0.61	0.56	0.05	0.65	0.52	0.10
MET	Manganese	260	AET-L	1.90	1.78	2.23	2.40	1.73	1.62	1.37	1.74	1.72	1.17	2.13
MET	Mercury	0.71	ER-M	0.67	0.74	0.20	0.68	1.28	1.18	0.33	2.07	1.77	1.19	0.41
MET	Molybdenum	NA	NA											
MET	Nickel	51.6	ER-M	2.31	2.09	1.16	3.10	2.34	2.48	1.80	3.12	2.52	2.38	1.68
MET	Selenium	1.0	AET-L	0.51	0.44	0.06	0.24	0.39	0.41	0.15	0.18	0.36	0.20	0.29
MET	Silver	3.7	ER-M	0.08	0.09	0.02	0.10	0.17	0.20	0.07	0.04	0.19	0.10	0.07
BT	DBT	NA	NA											
BT	MBT	NA	NA											
BT	TBT	3.4	AET-L	0.06	0.11	1.3E-4	0.02	8.1E-3	5.4E-3	5.0E-3	0.02	0.02	0.04	2.1E-4
BT	TTBT	NA	NA											
BT	Total Butyltins	NA	NA											
MET	Vanadium	NA	NA											
MET	Zinc	410	ER-M	0.50	0.41	0.19	0.44	0.60	0.65	0.51	0.72	0.59	0.52	0.26
MET	SEM-AVS	5	EPA	0.25	-0.50	-1.23	-1.86	-0.68	-2.21	-1.17	0.25	-1.52	-0.71	0.08
PAH	2-Methylnaphthalene	670	ER-M	0.03	0.02	2.4E-3	0.01	0.03	0.06	0.03	0.04	0.04	0.03	5.8E-3
PAH	Acenaphthene	500	ER-M	0.36	0.08	3.3E-3	0.02	0.02	0.02	0.02	0.04	0.01	0.02	5.0E-3
PAH	Acenaphthylene	640	ER-M	0.03	0.03	1.7E-3	0.02	0.02	0.02	0.02	0.05	0.02	0.07	7.8E-3
PAH	Anthracene	1100	ER-M	0.13	0.09	4.4E-3	0.06	0.04	0.05	0.05	0.21	0.03	0.17	0.01
PAH	Benzo(a)anthracene	1600	ER-M	0.38	0.22	8.0E-3	0.09	0.12	0.11	0.18	0.39	0.12	0.25	0.03
PAH	Benzo[a]pyrene	1600	ER-M	0.44	0.28	0.01	0.13	0.19	0.20	0.20	0.39	0.21	0.27	0.06
PAH	Benzo[b]fluoranthene	9900	AET-H	0.06	0.04	1.4E-3	0.02	0.02	0.02	0.03	0.05	0.03	0.03	6.3E-3
PAH	Benzo[ghi]perylene	2600	AET-H	0.18	0.13	8.1E-3	0.07	0.11	0.13	0.07	0.15	0.12	0.11	0.03
PAH	Benzo[k]fluoranthene	9900	AET-H	0.06	0.04	1.6E-3	0.02	0.03	0.03	0.03	0.05	0.03	0.03	6.1E-3
PAH	Chrysene	2800	ER-M	0.26	0.14	6.2E-3	0.09	0.10	0.09	0.16	0.27	0.10	0.20	0.02
PAH	Dibenz[a,h]anthracene	260	ER-M	0.36	0.24	6.3E-3	0.10	0.14	0.16	0.20	0.40	0.18	0.25	0.03
PAH	Fluoranthene	5100	ER-M	0.24	0.13	7.5E-3	0.06	0.08	0.07	0.09	0.19	0.06	0.13	0.02
PAH	Fluorene	540	ER-M	0.17	0.10	2.9E-3	0.02	0.02	0.04	0.03	0.15	0.02	0.09	7.6E-3
PAH	Indeno[1,2,3-cd]pyrene	2600	AET-L	0.19	0.13	6.6E-3	0.06	0.09	0.11	0.08	0.16	0.11	0.11	0.03
PAH	Naphthalene	2100	ER-M	8.7E-3	0.01	8.4E-4	7.1E-3	0.02	0.03	0.03	0.02	0.02	0.01	4.0E-3
PAH	Phenanthrene	1500	ER-M	0.50	0.25	0.01	0.09	0.10	0.10	0.10	0.45	0.07	0.31	0.03
PAH	Pyrene	2600	ER-M	0.52	0.29	0.02	0.13	0.18	0.17	0.20	0.41	0.16	0.29	0.06
PAH	Total LMW (L) PAHs	3160	ER-M	0.39	0.20	0.01	0.08	0.09	0.11	0.10	0.35	0.07	0.25	0.03
PAH	Total HMW (H) PAHs	9600	ER-M	0.49	0.28	0.01	0.13	0.17	0.17	0.22	0.43	0.16	0.30	0.05
PAH	Total PAHs	44792	ER-M	0.13	0.07	3.8E-3	0.03	0.04	0.04	0.05	0.12	0.04	0.08	0.01
PCB	Total PCBs	180	ER-M	3.92	0.61	0.12	2.37	8.70	11	4.61	29	10	0.02	0.03
PST	2,4'-DDD	27	ER-M	1.9E-3	1.9E-3	1.3E-3	1.7E-3	2.2E-3	2.0E-3	1.3E-3	1.5E-3	2.0E-3	1.3E-3	2.0E-3
PST	2,4'-DDE	27	ER-M	2.4E-3	2.4E-3	1.5E-3	2.2E-3	2.8E-3	2.4E-3	1.5E-3	1.9E-3	2.4E-3	1.5E-3	2.6E-3
PST	2,4'-DDT	27	ER-M	2.2E-3	2.2E-3	1.5E-3	2.0E-3	2.6E-3	2.4E-3	1.5E-3	1.7E-3	2.2E-3	1.5E-3	2.4E-3
PST	4,4'-DDD	27	ER-M	0.06	0.06	0.01	0.11	0.20	0.25	0.15	1.62	0.19	1.1E-3	0.02
PST	4,4'-DDE	27	ER-M	0.05	0.03	0.01	0.01	0.35	0.45	0.24	0.21	0.16	1.1E-3	0.01
PST	4,4'-DDT	27	ER-M	0.02	0.04	1.1E-3	0.03	0.03	0.03	1.1E-3	0.13	0.03	1.1E-3	1.9E-3
PST	alpha-Chlordane	4.79	PEL	0.04	0.04	5.2E-3	0.09	0.49	0.39	0.15	0.15	0.29	5.2E-3	4.2E-3
PST	Dieldrin	4.3	PEL	0.01	0.01	7.0E-3	0.10	0.84	4.74	0.29	8.1E-3	0.64	7.0E-3	0.01
PST	Endosulfan II	14	SQAL	3.6E-3	3.6E-3	2.1E-3	3.2E-3	3.9E-3	3.6E-3	2.1E-3	2.5E-3	3.6E-3	2.1E-3	3.6E-3
PST	Endrin	42	SQAL	1.1E-3	1.1E-3	7.1E-4	9.5E-4	1.2E-3	1.1E-3	7.1E-4	7.1E-4	1.1E-3	7.1E-4	1.1E-3
PST	gamma-Chlordane	4.8	PEL	8.4E-3	8.4E-3	5.2E-3	0.09	0.75	0.74	0.42	0.18	0.49	5.2E-3	8.4E-3
PST	Heptachlor	0.3	AET-L	0.13	0.13	0.08	0.12	0.15	0.13	0.08	0.10	0.13	0.08	0.15

LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene).
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene).
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2.
NA = benchmark not available.
Hazard Quotient = concentration(Appendix A-1-1)/benchmark(Table 2.2-1).

Appendix A-2-2. Hazard Quotients for pore water concentrations of chemicals in sediments collected for the Hunter's Point TIE investigation.

Class	Analyte	Benchmark	Benchmark Source	HP-01,PA-41(0-5 cm)	HP-02,PA-41(5-10 cm)	HP-03,EW-33(0-5 cm)	HP-04,OR-24(0-5 cm)	HP-05,SB-20(0-5 cm)	HP-06,SB-20(5-10 cm)	HP-07,SB-18(0-5 cm)	HP-08,SB-21(0-5 cm)	HP-09,SB-22(0-5 cm)	HP-10,SB-23(0-5 cm)	HP-REF,PC-63(0-5 cm)	HP-PC	HP-SPIKE
MET	Aluminum	750	WQC-FA	0.39	0.57	0.64	0.41	0.64	0.58	16	6.17	0.74	1.39	2.25	0.34	0.34
MET	Arsenic	69	WQC-SA	0.56	0.57	1.05	0.48	0.71	0.22	0.75	0.41	0.60	0.40	0.27	0.01	0.01
MET	Cadmium	42	WQC-SA	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3	6.4E-3
MET	Chromium	1100	WQC-SA	4.1E-3	4.4E-3	4.2E-3	4.4E-3	6.6E-3	6.4E-3	0.08	0.02	5.8E-3	7.6E-3	7.1E-3	3.1E-3	3.3E-3
MET	Copper	4.8	WQC-SA	1.71	1.10	1.35	0.94	2.35	1.81	27	9.69	2.04	3.73	2.42	0.71	66
MET	Iron	NA	NA													
MET	Lead	210	WQC-SA	0.02	0.02	0.02	0.02	0.02	0.02	0.41	0.09	0.02	0.02	0.02	0.02	0.02
MET	Manganese	1000	WQC-FA	4.12	2.32	2.45	3.59	4.59	1.86	1.67	8.35	5.57	2.04	14	6.0E-4	6.0E-4
MET	Nickel	74	WQC-SA	0.11	0.09	0.12	0.07	0.10	0.07	0.75	0.27	0.07	0.15	0.18	0.02	0.02
MET	Silver	1.9	WQC-SA	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
MET	Zinc	90	WQC-SA	0.24	0.45	0.22	0.25	0.22	0.18	2.40	0.60	0.28	0.51	0.30	0.69	0.20
MET	SEM-AVS	NA	NA													
PAH	2-Methylnaphthalene	300	WQC-SA	7.9E-4	5.7E-4	7.4E-5	2.3E-4	5.2E-4	1.0E-3	2.0E-3	1.6E-3	5.9E-4	1.1E-3	1.7E-4		
PAH	Acenaphthene	1700	WQC-FA	1.4E-3	3.1E-4	1.5E-5	3.6E-5	3.9E-5	6.0E-5	2.2E-4	2.5E-4	3.4E-5	1.4E-4	2.1E-5		
PAH	Acenaphthylene	300	WQC-SA	5.8E-4	5.6E-4	4.3E-5	2.0E-4	2.3E-4	3.1E-4	1.0E-3	1.6E-3	2.5E-4	2.2E-3	1.8E-4		
PAH	Anthracene	300	WQC-SA	1.5E-3	1.0E-3	6.1E-5	3.9E-4	2.9E-4	4.1E-4	1.3E-3	3.8E-3	2.3E-4	3.0E-3	1.8E-4		
PAH	Benzo(a)anthracene	300	WQC-SA	4.6E-4	2.6E-4	1.2E-5	7.2E-5	9.5E-5	9.3E-5	5.6E-4	7.6E-4	9.7E-5	4.7E-4	3.9E-5		
PAH	Benzo[a]pyrene	300	WQC-SA	2.1E-4	1.3E-4	7.9E-6	3.8E-5	6.0E-5	6.5E-5	2.4E-4	3.0E-4	6.6E-5	2.0E-4	3.3E-5		
PAH	Benzo[b]fluoranthene	300	WQC-SA	1.4E-4	8.4E-5	4.1E-6	2.3E-5	3.9E-5	4.0E-5	1.7E-4	1.9E-4	4.0E-5	1.2E-4	1.7E-5		
PAH	Benzo[ghi]perylene	300	WQC-SA	3.8E-5	2.5E-5	2.0E-6	8.4E-6	1.6E-5	1.7E-5	3.9E-5	4.8E-5	1.6E-5	3.5E-5	7.8E-6		
PAH	Benzo[k]fluoranthene	0.8	estimated	0.05	0.03	1.8E-3	9.8E-3	0.02	0.02	0.07	0.07	0.02	0.05	6.3E-3		
PAH	Chrysene	300	WQC-SA	5.5E-4	2.9E-4	1.6E-5	1.2E-4	1.4E-4	1.3E-4	8.7E-4	9.0E-4	1.3E-4	6.6E-4	5.5E-5		
PAH	Dibenz[a,h]anthracene	300	WQC-SA	7.8E-6	4.9E-6	1.6E-7	1.3E-6	1.9E-6	2.3E-6	1.1E-5	1.3E-5	2.4E-6	8.2E-6	7.3E-7		
PAH	Fluoranthene	3980	WQC-FA	2.6E-4	1.4E-4	9.9E-6	3.9E-5	5.8E-5	4.9E-5	2.5E-4	3.2E-4	4.4E-5	2.2E-4	2.8E-5		
PAH	Fluorene	300	WQC-SA	2.1E-3	1.1E-3	4.2E-5	1.6E-4	1.7E-4	3.1E-4	8.9E-4	2.9E-3	1.5E-4	1.7E-3	1.0E-4		
PAH	Indeno[1,2,3-cd]pyrene	300	WQC-SA	4.5E-5	3.0E-5	1.9E-6	8.2E-6	1.4E-5	1.6E-5	4.6E-5	5.8E-5	1.6E-5	4.1E-5	8.0E-6		
PAH	Naphthalene	2300	WQC-FA	3.7E-4	4.8E-4	4.2E-5	1.8E-4	5.3E-4	7.9E-4	2.8E-3	1.3E-3	5.4E-4	7.8E-4	1.9E-4		
PAH	Phenanthrene	30	WQC-FA	0.08	0.04	2.3E-3	8.7E-3	0.01	0.01	0.04	0.11	6.8E-3	0.08	5.9E-3		
PAH	Pyrene	300	WQC-SA	3.9E-3	2.1E-3	1.6E-4	5.9E-4	9.0E-4	8.4E-4	3.8E-3	4.9E-3	7.5E-4	3.4E-3	4.9E-4		
PAH	Total LMW (L) PAHs	300	WQC-SA	0.02	0.01	8.6E-4	3.5E-3	6.6E-3	9.4E-3	0.03	0.03	6.2E-3	0.02	2.8E-3		
PAH	Total HMW (H) PAHs	300	WQC-SA	8.6E-3	4.7E-3	3.3E-4	1.3E-3	2.0E-3	1.8E-3	8.8E-3	0.01	1.6E-3	7.6E-3	9.9E-4		
PAH	Total PAHs	300	WQC-SA	0.03	0.02	1.2E-3	4.8E-3	8.5E-3	0.01	0.04	0.04	7.9E-3	0.03	3.7E-3		
PCB	Total PCBs	2.0	WQC-FA	0.01	1.8E-3	4.5E-4	4.5E-3	0.02	0.02	0.04	0.14	0.02	8.5E-5	1.2E-4		
PST	2,4'-DDD	2.7E-3	estimated	1.7E-3	1.6E-3	1.4E-3	9.5E-4	1.4E-3	1.2E-3	3.0E-3	2.2E-3	1.2E-3	1.9E-3	2.1E-3		
PST	2,4'-DDE	6.1E-4	estimated	2.2E-3	2.1E-3	1.7E-3	1.3E-3	1.7E-3	1.5E-3	3.4E-3	2.7E-3	1.4E-3	2.1E-3	2.7E-3		
PST	2,4'-DDT	6.1E-4	estimated	2.1E-3	2.0E-3	1.7E-3	1.2E-3	1.6E-3	1.5E-3	3.4E-3	2.4E-3	1.3E-3	2.1E-3	2.5E-3		
PST	4,4'-DDD	0.6	WQC-FA	2.7E-4	2.5E-4	5.1E-5	3.0E-4	5.5E-4	6.9E-4	1.6E-3	0.01	5.0E-4	7.2E-6	7.4E-5		
PST	4,4'-DDE	1050	WQC-FA	3.0E-8	1.6E-8	7.5E-9	4.1E-9	1.3E-7	1.6E-7	3.2E-7	1.7E-7	5.4E-8	9.3E-10	7.3E-9		
PST	4,4'-DDT	1.1	WQC-FA	1.2E-5	1.9E-5	6.9E-7	9.2E-6	1.2E-5	8.7E-6	1.4E-6	1.1E-4	9.4E-6	8.9E-7	1.1E-6		
PST	alpha-Chlordane	2.0E-4	estimated	0.04	0.03	5.8E-3	0.05	0.30	0.24	0.34	0.21	0.17	7.5E-3	4.3E-3		
PST	Dieldrin	0.7	WQC-SA	3.4E-5	2.9E-5	2.5E-5	1.9E-4	1.6E-3	9.2E-3	2.1E-3	3.8E-5	1.2E-3	3.2E-5	3.8E-5		
PST	Endosulfan II	0.1	estimated	3.3E-3	3.1E-3	2.4E-3	1.8E-3	2.4E-3	2.2E-3	4.9E-3	3.6E-3	2.1E-3	3.1E-3	3.7E-3		
PST	Endrin	0.0	WQC-SA	1.2E-3	1.1E-3	9.6E-4	6.6E-4	8.8E-4	7.9E-4	2.0E-3	1.2E-3	7.6E-4	1.2E-3	1.3E-3		
PST	gamma-Chlordane	2.9E-4	estimated	7.7E-3	7.4E-3	5.8E-3	0.05	0.46	0.45	0.97	0.26	0.29	7.5E-3	8.6E-3		
PST	Heptachlor	0.1	WQC-SA	2.8E-5	2.7E-5	2.2E-5	1.5E-5	2.1E-5	1.9E-5	4.4E-5	3.3E-5	1.8E-5	2.8E-5	3.6E-5	3.2E-5	3.5E-5
AMM	Un-ionized Ammonia	0.23	WQC-SA	0.82	0.77	9.31	3.69	2.58	0.26	1.37	3.52	4.68	5.54	0.52	0.09	0.39

Benchmark is for Chromium VI. Measured concentration is for total Chromium.
LMW PAH = sum of 7 2-ring & 3-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene).
HMW PAH = sum of 6 4-ring and 5-ring PAHs included in NOAA ER-L/ER-M benchmarks (Long et al. 1995);
(benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene).
Total PAHs - sum of LMW & HMW PAHs; Total PCBs - Sum of individual PCB congeners x 2.
Hazard Quotient for metals = concentration(Appendix A-1-3)/benchmark(Table 2.2-2).
Hazard Quotient for organics = concentration(Appendix A-1-4)/benchmark(Table 2.2-2);
if estimated benchmark used, benchmark x %TOC(Appendix A-1-1). NA = benchmark not available.

Appendix A-3. Calculation of pore water unionized ammonia concentrations and species-specific Hazard Quotients for the Hunter's Point TIE study.

a) Fish (*Menidia menidia*)

Sample ID	Total Ammonia (mg/L)	Temp (C)	pH	Un-ionized Ammonia[1] (mg/L)	Un-ionized Ammonia HQ[2]	HQ Interpretation[3]
HP-1	3.50	20	8.40	0.26	0.18	-
HP-2	4.25	20	8.30	0.25	0.17	-
HP-3	27	20	8.60	2.94	2.03	+
HP-4	13	20	8.50	1.17	0.81	-
HP-5	11	20	8.40	0.82	0.57	-
HP-6	1.50	20	8.30	0.09	0.06	-
HP-7	18	20	7.90	0.44	0.30	-
HP-8	30	20	8.10	1.14	0.79	-
HP-9	17	20	8.50	1.49	1.03	+
HP-10	30	20	8.30	1.77	1.22	+
HP-REF[5]	2.80	20	8.30	0.17	0.12	-
HP-PC	1.25	20	7.80	0.02	0.02	-
HP-Spike[4]	5.00	20	7.90	0.12	0.08	-

b) Urchin (*Strongylocentrotus purpuratus*)

Sample ID	Total Ammonia (mg/L)	Temp (C)	pH	Un-ionized Ammonia[1] (mg/L)	Un-ionized Ammonia HQ[2]	HQ Interpretation[3]
HP-1	3.50	15	8.40	0.19	3.11	++
HP-2	4.25	15	8.30	0.18	3.04	++
HP-3	27	15	8.60	2.17	36	+++
HP-4	13	15	8.50	0.86	14	+++
HP-5	11	15	8.40	0.60	10	+++
HP-6	1.50	15	8.30	0.06	1.07	+
HP-7	18	15	7.90	0.32	5.25	++
HP-8	30	15	8.10	0.82	14	+++
HP-9	17	15	8.50	1.09	18	+++
HP-10	30	15	8.30	1.29	21	+++
HP-REF[5]	2.8	15	8.30	0.12	2.00	+
HP-PC	1.25	15	7.80	0.02	0.29	-
HP-Spike[4]	5.00	15	7.90	0.09	1.46	+

c) Sand Dollar (*Dendraster excentricus*)

Sample ID	Total Ammonia (mg/L)	Temp (C)	pH	Un-ionized Ammonia[1] (mg/L)	Un-ionized Ammonia HQ[2]	HQ Interpretation[3]
HP-1						
HP-2						
HP-3						
HP-4	23	15	8.50	1.52	25	+++
HP-5	24	15	8.40	1.28	21	+++
HP-6						
HP-7						
HP-8						
HP-9	26	15	8.50	1.72	29	+++
HP-10						
HP-REF	4.30	15	8.30	0.18	3.07	++
HP-PC	0.80	15	8.00	0.02	0.29	-

1 - Unionized ammonia = Total ammonia/(1+10(pK+0.0324(298-Temp.(K))+0.0415(1/Temp.(K))-pH)); (Hampson 1977); calculated for the untreated TIE treatment.

2- Hazard Quotient (HQ) = Unionized Ammonia Conc./median of LC_{50} or EC_{50} "benchmark" reported in Table 2.2-3.

3 - Hazard Quotient (see Appendix A-2-2 for values) codes: <benchmark(BM) = "-"; >BM = "+"; >3xBM = "++"; >10xBM = "+++".

4 - pH estimated as median of pH measured during toxicity testing (Table 2.4-1).

5 - Data source: bulk sediment test with *E. estuarius* , Battelle, 2001.

Appendix A-4. Statistical summary of moisture content and grain size data for sediments collected for the Hunter's Point TIE investigation[1].

Percent content

Station	Moisture Content[1]	Coarse Gravel	Fine Gravel	Total Gravel	Coarse Sand	Medium Sand	Fine Sand	Total Sand	Fines	Total
HP-01,PA-41(0-5 cm)	55.3	0.0	0.0	0.0	0.0	2.9	17.1	20.0	80.0	100
HP-02,PA-41(5-10 cm)	51.7	0.0	5.4	5.4	0.8	4.8	17.3	22.9	71.7	100
HP-03,EW-33(0-5 cm)	31.8	0.0	0.0	0.0	0.0	10.8	74.8	85.6	14.4	100
HP-04,OR-24(0-5 cm)	39.3	0.0	0.0	0.0	0.0	3.3	42.8	46.1	53.9	100
HP-05,SB-20(0-5 cm)	50.0	0.0	0.0	0.0	0.0	0.4	6.9	7.3	92.7	100
HP-06,SB-20(5-10 cm)	53.8	0.0	0.0	0.0	0.0	0.4	6.9	7.3	92.7	100
HP-07,SB-18(0-5 cm)	25.5	0.0	0.0	0.0	0.0	0.7	83.5	84.2	15.8	100
HP-08,SB-21(0-5 cm)	38.8	0.0	0.0	0.0	0.3	7.0	64.5	71.8	28.2	100
HP-09,SB-22(0-5 cm)	55.2	0.0	0.0	0.0	0.0	0.8	11.8	12.6	87.4	100
HP-10,SB-23(0-5 cm)	31.8	0.0	0.0	0.0	0.0	22.6	58.2	80.8	19.2	100
HP-REF,PC-63(0-5 cm)	57.1	0.0	0.0	0.0	0.0	0.0	1.7	1.7	98.3	100

1 - Data source (except moisture content): Battelle, 2001.

2 - measured during SEM/AVS analysis.

APPENDIX B-1
TIE Toxicity Lab Reports

APPENDIX B-1-1
Screening Lab Report

Aquatec Biological Sciences

August 6, 2001

Ms. Sherry Poucher
SAIC
221 Third Street
Newport, Rhode Island 02840

Dear Ms. Poucher:

Enclosed please find a report (two copies) of the results (tabulated and copies of bench sheets), methods, and qualifiers for screening toxicity tests completed for the Hunter's Point sediment porewater samples (SDG 5238). These tests were run as preliminary screening tests for the Hunter's Point sediment porewater TIE investigation, reported separately (SDG 5254).

If you have any questions regarding the report, please contact Dr. Philip C. Downey or me.

Sincerely,

John Williams
Manager, Environmental Toxicology

373 Commerce Street, Williston, VT 05495 Tel 802 860 1638 Fax

Aquatec Biological Sciences

Toxicity Screen Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/2/01
Project: 01025
SDG 5238
Site: Hunters Pt. TIE

Method: SPScreen Species: *Strongylocentrotus purpuratus*

Number	Sample Name	HP Sample Name	Conc (%)	Day	Start	Replicate Normal Development 1	2	3
020384	Duxbury Seawater		100	3	100	95	89	93
019759	EW-33-SS1	HP:3	100	3	100	0	0	0
019760	SB-23-SS1	HP:10	100	3	100	0	0	0
019761	SB-20-SS1	HP:5	100	3	100	0	0	0
019762	SB-18-SS1	HP:7	100	3	100	0	0	0
019763	OR-24-SS1	HP:4	100	3	100	0	0	0
019764	SB-19-SS1		100	3	100	0	0	0
019765	SB-20-SS2	HP:6	100	3	100	0	0	0
019766	PA-41-SS1	HP:1	100	3	100	0	0	0
019767	PA-41-SS2	HP:2	100	3	100	0	0	0
019768	PC-63-SS1	REF	100	3	100	0	0	0
019769	SB-21-SS1	HP:8	100	3	100	0	0	0
019770	SB-22-SS1	HP:9	100	3	100	0	0	0

273 Commerce Street, Williston, VT 05495 Tel 802.860.1638 Fax

Toxicity Screen Report

Science Applications International Corp	Date:	8/2/01
221 Third Street	Project:	01025
	SDG	5238
Newport, RI 02840	Site:	Hunters Pt. TIE

Special Conditions and Qualifiers

Qualifiiers

Porewater dissolved oxygen concentrations were measured prior to initiating toxicity tests. Several of the porewater samples had low dissolved oxygen concentrations (< 4.0 mg/L), including samples 19759 (EW-33-SS1), 19760 (SB-23-SS1), and 19762 (SB-18-SS1). The porewater for these samples was aerated approximately 1 hour to raise the dissolved oxygen concentration above 6 mg/L before dispensing the porewater to the test vials.

Submitted By:

Supportive Documentation

Chain-Of-Custody

Toxicity Test Methods

Screening test, Strongylocentrotus purpuratus

Standard Reference Toxicant Control Charts

Available Upon Request

Science Applications International Corporation

APPENDIX B-1-2
TIE Toxicity Lab Report

Aquatec Biological Sciences

August 6, 2001

Ms. Sherry Poucher
SAIC
221 Third Street
Newport, Rhode Island 02840

Dear Ms. Poucher:

Enclosed please find a report (two copies) of the results, methods, and narrative for toxicity testing completed for the Hunter's Point sediment porewater TIE study (SDG 5254). The following text files have also been sent to you by e-mail:

5254DE
5254MM
5254SP

If you have any questions regarding the report, please contact me or Dr. Philip C. Downey.

Sincerely,

John Williams
Manager, Environmental Toxicology

[illegible] Commerce Street, Williston, VT 05495 Tel 802.860.1638 Fax 802.[illegible]

Aquatec Biological Sciences

Narrative

Science Applications International Corp	Date:	8/3/01
221 Third Street	Project:	01025
	SDG:	5254
Newport, RI 02840	Site:	Hunter's Pt TIE

General comments:

Centrifugation: Porewaters for sediment samples 19759 (EW-33-SS1/HP-3), 19760 (SB-23-SS1/HP10), 19761 (SB-20-SS1/HP-5), 19763 (OR-24-SS1), 19765 (SB-20-SS2/HP-6), and 19766 (PA-41-SS1/HP1), and 19970 (SB-22-SS1/HP-9) tests were extracted by centrifuge on June 4, 2001 using a IEC PR7000 centrifuge (30 min at 5200 rpm). Porewaters for sediment samples 19762 (SB-18-SS1/HP-7), 19767 (PA-41-SS2/HP-2), 19768 (PC-63-SS1/REF), and 19769 (SB-21-SS1/HP8) were extracted by centrifuge on June 5, 2001 using a IEC B-22M centrifuge (15 min at 7500 rpm). Porewaters were shipped to SAIC on June 5, 2001. Sediment sample 19764 (SB-19-SS1) was not extracted due to the sand/gravel character with apparently little porewater.

Test starts: Porewaters for TIE testing were received on June 8, 2001. The *Menidia menidia* and the *Strongylocentrotus purpuratus* toxicity tests were started on the same day as samples were received.

Use of oxygen: Several porewater samples received for the TIE exhibited low dissolved oxygen concentrations when measured prior to testing. Samples with dissolved oxygen measurements of less than 7 mg/L oxygenated by bubbling pure oxygen through the solutions until the dissolved oxygen concentration was greater than 18 mg/L. Samples treated with oxygen were noted on the bench sheets.

High pH exposure system: The high pH test vials were isolated in a large, sealed plastic box. Four small beakers containing a 5% KOH solution with a paper-towel wick were placed within the plastic box with the vials to elevate the pH of solutions with the test vials.

Sample not tested: A sample for HP-7 Filtered was not received and therefore was not tested as part of the TIE.

Initial chemistry: Initial chemistry measurements (100% porewater) were measured before distributing test solutions to test vials. The measurements are common to toxicity tests for both species.

Final chemistry: Final chemistry measurements (of 10%, 25%, 50%, and 100% porewater) were completed in a set of vials not containing test organisms. The final chemistry vials were held at approximately 20°C for Days 0, 1, and 2 and then transferred to an incubator and held at approximately 15 °C from Day 2 to Day 3 when the sea urchin development test was ended.

Comments specific to the *Menidia menidia* toxicity tests:

Shortage of organisms: A combination of embryos and larvae were used for the porewater TIE tests for this species due to a shortage of both embryos and larvae to run the tests uniformly with either life stage. In general, embryos were used for the 50% test concentration and larvae were used for the 100% test concentration. Concentrations of 10% or 25% were not tested. Also, due to the shortage of embryos, in general only two replicates rather than three were tested for the 50% concentration. For some treatments (e.g., High pH), only two replicates were tested for the 100% porewater due to organism limitations. A standard reference toxicant (SRT) test for *Menidia menidia* was not performed due to insufficient organisms for SRT testing.

Dissolved oxygen: On Day 1 no surviving larvae were remaining in the 100% concentration for several of the TIE porewaters (with the exception of the *Ulva* treatment) for samples HP3, HP-8, and HP-10. The measured dissolved oxygen concentrations were less than 3 mg/L in the test vials on Day 1 for those vials where 100% mortality was observed for HP3, HP-8, and HP-10.

Detox not tested: The Detox treatment was not tested with *Menidia Menidia*.

Photoactivation: On Day 2 (June 10, 2001) all test vials were moved outside for photoactivation a spiked compound as requested by SAIC. The ambient air temperature was measured as 19.2°C and the condition was partly cloudy when the outdoor 4-hour exposure was started. When the outdoor exposure was completed it was discovered that the temperature of the test vials had risen above the target temperature range. Temperatures exceeding 30°C were measured, therefore it is possible that heat-related stress resulted in organism mortality on Day 2.

Day 1 test data reported: Survival data for Day 1 were reported, rather than the Day 2 data since the photoactivation procedure may have affected organism survival on Day 2. On Day 2 the final number of surviving larvae were recorded on the bench sheets but the data were not tabulated for reporting purposes.

Comments specific to the *Strongylocentrotus purpuratus* toxicity tests:

Screening-level toxicity tests: Screening-level toxicity tests (undiluted porewater) were conducted with sea urchin embryos from June 1-June 4, 2001. Porewater for the screening toxicity tests was collected by the syringe method (from May 31-June 1, 2001). A control consisting of Cape Cod Bay seawater was included in the test array. A standard reference toxicant (SRT, $CuSO_4$) test using Cape Cod Bay as dilution water was also performed. The EC50 (22.7 ug/L) for the SRT fell within the Aquatec Biological Sciences, Inc. control chart limits (13.5-38.8 ug/L).

Replicates not tested: A few replicates for the sea urchin embryo development tests were not included in the overall test array for the porewater TIE. These included Filtered HP-8 (50% and 100%, not tested). Two vials for the *Ulva* HP-8 50% had very low solution volumes that may have affected embryo development (no normal embryos observed). The data for these vials were excluded from the data tabulation.

Tests not scored: The TIE exposures for the Detox treatment and the High pH treatments were performed, however the embryos for these manipulations were not scored, as specified by SAIC.

Performance control responses: Embryos in the untreated and manipulated performance controls had less than 80% normal development. A series of seawater test trials performed subsequent to the TIE suggested that the batch of seawater used for the TIE performance controls and also as dilution water for the TIE may have contributed to abnormal embryo development. Copies of data generated for the seawater trials are included in the data package.

Dissolved oxygen: Low dissolved oxygen concentrations (<3 mg/L) were observed at the end of the test (as measured in the chemistry vials) for several of the porewater samples – most commonly in the 100% porewater solutions. The data were recorded on the final chemistry bench sheets.

Generally, decreasing dissolved oxygen concentrations were observed to correspond to increasing concentration of porewater, however, for the High pH treatments of samples 19901 (HP-5), 19902 (HP-6), and 19905 (HP-9) a trend of increasing dissolved oxygen concentration was observed with increasing porewater concentration (the lowest dissolved oxygen concentrations were observed in the 10% solution). It is possible that the measurements for these tests were measured or recorded in an incorrect order.

Standard reference toxicant test: A SRT test conducted concurrently with the sea urchin embryo TIE tests was not plotted on the Aquatec Biological Sciences, Inc. control chart because the seawater control (Narragansett Bay Seawater) did

not meet the acceptance criterion of at least 80% normally developed. A copy of the SRT test data is included in the data package.

Comments specific to the *Dendraster excentricus* toxicity tests:

Porewater extraction: Porewaters for the sand dollar embryo development tests were extracted using a IEC B-22-M centrifuge on June 25, 2001 from sediment samples 19763 (OR-24-SS1/HP-4), 19761 (SB-20-SS1/HP5), 19770 (SB-22-SS1/HP9), and 19768 (PC-63-SS1/REF) and shipped to SAIC for TIE manipulations.

Test starts: TIE porewaters were received on June 29, 2001 and the sand dollar embryo development tests were started on the same day.

High pH test: The test vials for the High pH TIE were tested without the 5% KOH exposure system.

Dissolved oxygen: Porewater samples prepared for testing on June 29, 2001 did not exhibit very low dissolved oxygen concentrations. The lowest observed dissolved oxygen concentration in 100% porewater was 6.2 mg/L, therefore, the samples were prepared for testing without the use of pure oxygen or aeration prior to testing. At the end of the test, low dissolved oxygen concentrations (<3.0 mg/L) were observed in the *Ulva* 1st thiosulfate and the *Ulva* 1st EDTA treatments of samples 20170 (HP-5), 20171 (HP-9), 20175 (HP-5), and 20176 (HP-9) and also in the Oasis treatment for 20149 (HP-4).

Scoring of embryos: In scoring the embryos for normal / abnormal development, some of the transitional concentrations had embryos which appeared to be normally shaped but were somewhat stunted in size. These were generally judged to be "normal" and an annotation regarding the observation was recorded on the bench sheet.

Vial not preserved: One replicate of the Ulva 1st thiosulfate 10% treatment apparently was not preserved with formalin when the test was ended, because the embryos were found to be degraded.

Aquatec Biological Sciences

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: Control Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019818	Untreated	100	1	5	5	4	3
019831	Thiosulfate	100	1	5	3	4	4
019844	EDTA	100	1	5	4	2	3
019857	Filtered	100	1	5	4	2	3
019869	Oasis	100	1	5	4	3	3
019895	Ph high	100	1	5	5	4	4
019908	Ulva	100	1	5	5	4	5

273 Commerce Street, Williston VT 05495 Tel 802.860.1638 Fax 802.655.[illegible]

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:1 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019820	Untreated	50	1	5	5	5	
019820	Untreated	100	1	5	4	5	3
019833	Thiosulfate	50	1	5	5	5	
019833	Thiosulfate	100	1	5	5	4	5
019846	EDTA	50	1	5	5	5	
019846	EDTA	100	1	5	5	5	5
019859	Filtered	50	1	5	5	5	5
019859	Filtered	100	1	5	5	5	5
019871	Oasis	50	1	5	5	5	
019871	Oasis	100	1	5	5	3	4
019897	Ph high	50	1	5	5	5	5
019897	Ph high	100	1	5	5	5	
019910	Ulva	50	1	5	5	5	
019910	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:10 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019829	Untreated	50	1	5	5	5	
019829	Untreated	100	1	5	0	0	0
019842	Thiosulfate	50	1	5	5	5	
019842	Thiosulfate	100	1	5	0	0	0
019855	EDTA	50	1	5	5	5	
019855	EDTA	100	1	5	0	0	0
019867	Filtered	50	1	5	5	5	
019867	Filtered	100	1	5	0	0	0
019880	Oasis	50	1	5	5	5	
019880	Oasis	100	1	5	0	0	0
019906	Ph high	50	1	5	5	5	5
019906	Ph high	100	1	5	0		
019919	Ulva	50	1	5	5	5	
019919	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:2 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019821	Untreated	50	1	5	5	5	
019821	Untreated	100	1	5	5	5	5
019834	Thiosulfate	50	1	5	5	5	
019834	Thiosulfate	100	1	5	3	4	5
019847	EDTA	50	1	5	5	5	
019847	EDTA	100	1	5	5	5	5
019860	Filtered	50	1	5	5	5	
019860	Filtered	100	1	5	5	5	5
019872	Oasis	50	1	5	5	5	
019872	Oasis	100	1	5	2	4	3
019898	Ph high	50	1	5	5	5	5
019898	Ph high	100	1	5	5	5	
019911	Ulva	50	1	5	5	5	
019911	Ulva	100	1	5	4	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:3 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019822	Untreated	50	1	5	5	5	
019822	Untreated	100	1	5	0	0	0
019835	Thiosulfate	50	1	5	5	5	
019835	Thiosulfate	100	1	5	0	0	0
019848	EDTA	50	1	5	4	5	
019848	EDTA	100	1	5	0	0	0
019861	Filtered	50	1	5	5	5	
019861	Filtered	100	1	5	0	0	0
019873	Oasis	50	1	5	4	5	
019873	Oasis	100	1	5	0	0	0
019899	Ph high	50	1	5	5	5	5
019899	Ph high	100	1	5	0	0	
019912	Ulva	50	1	5	5	5	
019912	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:4 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019823	Untreated	50	1	5	5	5	
019823	Untreated	100	1	5	3	2	2
019836	Thiosulfate	50	1	5	5	5	
019836	Thiosulfate	100	1	5	5	5	5
019849	EDTA	50	1	5	5	5	
019849	EDTA	100	1	5	5	5	5
019862	Filtered	50	1	5	5	5	
019862	Filtered	100	1	5	5	5	5
019874	Oasis	50	1	5	5	5	
019874	Oasis	100	1	5	4	5	4
019900	Ph high	50	1	5	5	5	5
019900	Ph high	100	1	5	2	3	
019913	Ulva	50	1	5	5	5	
019913	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:5 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019824	Untreated	50	1	5	5	5	
019824	Untreated	100	1	5	0	1	0
019837	Thiosulfate	50	1	5	5	5	
019837	Thiosulfate	100	1	5	1	1	1
019850	EDTA	50	1	5	5	5	
019850	EDTA	100	1	5	1	0	1
019863	Filtered	50	1	5	5	5	
019863	Filtered	100	1	5	4	5	4
019875	Oasis	50	1	5	5	5	
019875	Oasis	100	1	5	0	0	1
019901	Ph high	50	1	5	5	5	5
019901	Ph high	100	1	5	4	4	3
019914	Ulva	50	1	5	5	5	
019914	Ulva	100	1	5	4	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:6 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019825	Untreated	50	1	5	5	5	
019825	Untreated	100	1	5	5	5	5
019838	Thiosulfate	50	1	5	5	5	
019838	Thiosulfate	100	1	5	5	5	5
019851	EDTA	50	1	5	5	5	
019851	EDTA	100	1	5	4	5	5
019864	Filtered	50	1	5	5	5	
019864	Filtered	100	1	5	5	5	5
019876	Oasis	50	1	5	5	5	
019876	Oasis	100	1	5	4	3	4
019902	Ph high	50	1	5	5	5	5
019902	Ph high	100	1	5	5	5	
019915	Ulva	50	1	5	5	5	
019915	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:7 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019826	Untreated	50	1	5	5	5	
019839	Thiosulfate	50	1	5	5	5	
019839	Thiosulfate	100	1	5	0		
019852	EDTA	50	1	5	5	5	
019852	EDTA	100	1	5	0		
019877	Oasis	50	1	5	5	5	
019877	Oasis	100	1	5	0	0	0
019903	Ph high	50	1	5	5	5	5
019903	Ph high	100	1	5	5	1	
019916	Ulva	50	1	5	5	5	
019916	Ulva	100	1	5	4	4	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:8 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019827	Untreated	50	1	5	5	5	
019827	Untreated	100	1	5	0	0	0
019840	Thiosulfate	50	1	5	5	5	
019840	Thiosulfate	100	1	5	0	0	0
019853	EDTA	50	1	5	5	5	
019853	EDTA	100	1	5	0	0	0
019865	Filtered	50	1	5	5	5	
019865	Filtered	100	1	5	0	0	0
019878	Oasis	50	1	5	5	5	
019878	Oasis	100	1	5	0	0	0
019904	Ph high	50	1	5	5	5	5
019904	Ph high	100	1	5	0	0	
019917	Ulva	50	1	5	5	5	
019917	Ulva	100	1	5	5	4	4

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:9 Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019828	Untreated	50	1	5	5	5	
019828	Untreated	100	1	5	0	0	0
019841	Thiosulfate	50	1	5	5	5	
019841	Thiosulfate	100	1	5	0	0	0
019854	EDTA	50	1	5	5	5	
019854	EDTA	100	1	5	0	0	2
019866	Filtered	50	1	5	5	5	
019866	Filtered	100	1	5	2	4	1
019879	Oasis	50	1	5	5	5	
019879	Oasis	100	1	5	1	1	3
019905	Ph high	50	1	5	5	5	5
019905	Ph high	100	1	5	2	3	
019918	Ulva	50	1	5	5	5	
019918	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: REF Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019830	Untreated	50	1	5	5	5	
019830	Untreated	100	1	5	5	4	5
019843	Thiosulfate	50	1	5	5	5	
019843	Thiosulfate	100	1	5	5	4	5
019856	EDTA	50	1	5	5	5	
019856	EDTA	100	1	5	4	5	5
019868	Filtered	50	1	5	4	5	
019868	Filtered	100	1	5	5	5	5
019881	Oasis	50	1	5	5	5	
019881	Oasis	100	1	5	4	4	5
019907	Ph high	50	1	5	5	5	5
019907	Ph high	100	1	5	5	5	
019920	Ulva	50	1	5	5	5	
019920	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: Spike Method: A48MMS Species: *Menidia menidia*

					Replicate Survival		
Number	Treatment	Conc (%)	Day	Start	1	2	3
019819	Untreated	50	1	5	5	5	
019819	Untreated	100	1	5	1	0	0
019832	Thiosulfate	50	1	5	5	5	
019832	Thiosulfate	100	1	5	3	3	1
019845	EDTA	50	1	5	5	5	
019845	EDTA	100	1	5	2	4	2
019858	Filtered	50	1	5	5	5	5
019858	Filtered	100	1	5	4	4	4
019870	Oasis	50	1	5	5	5	
019870	Oasis	100	1	5	3	4	4
019896	Ph high	50	1	5	5	5	5
019896	Ph high	100	1	5	4	4	4
019909	Ulva	50	1	5	5	4	
019909	Ulva	100	1	5	5	5	5

Toxicity Detail Report

Science Applications International Corp	Date:	8/3/01
221 Third Street	Project:	01025
	SDG	5254
Newport, RI 02840	Site:	Hunters Pt TIE

Submitted By: _____

Aquatec Biological Sciences

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: Control Method: C72SPED Species: *Strongylocentrotus purpuratus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
019818	Untreated	100	3	100	61	61	56
019831	Thiosulfate	100	3	100	75	80	78
019844	EDTA	100	3	100	69	69	64
019857	Filtered	100	3	100	60	69	70
019869	Oasis	100	3	100	60	55	59
019908	Ulva	100	3	100	67	67	66

273 Commerce Street, Williston, VT 05495 Tel 802.860.1638 Fax 802.658.[illegible]

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:1 Method: C72SPED Species: *Strongylocentrotus purpuratus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
019820	Untreated	10	3	100	13	0	23
019820	Untreated	25	3	100	1	0	0
019820	Untreated	50	3	100	0	0	0
019820	Untreated	100	3	100	0	0	0
019833	Thiosulfate	10	3	100	36	50	54
019833	Thiosulfate	25	3	100	25	23	21
019833	Thiosulfate	50	3	100	0	0	0
019833	Thiosulfate	100	3	100	0	0	0
019846	EDTA	10	3	100	63	61	66
019846	EDTA	25	3	100	36	30	25
019846	EDTA	50	3	100	0	0	0
019846	EDTA	100	3	100	0	0	0
019859	Filtered	10	3	100	61	56	55
019859	Filtered	25	3	100	27	26	29
019859	Filtered	50	3	100	0	0	0
019859	Filtered	100	3	100	0	0	0
019871	Oasis	10	3	100	27	32	39
019871	Oasis	25	3	100	13	12	10
019871	Oasis	50	3	100	0	0	0
019871	Oasis	100	3	100	0	0	0
019910	Ulva	10	3	100	60	44	47
019910	Ulva	25	3	100	52	40	38
019910	Ulva	50	3	100	50	44	49
019910	Ulva	100	3	100		49	58
019910	Ulva	100	3	80	47		

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:10 Method: C72SPED Species: *Strongylocentrotus purpuratus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
019829	Untreated	10	3	100	0	0	0
019829	Untreated	25	3	100	0	0	0
019829	Untreated	50	3	100	0	0	0
019829	Untreated	100	3	100	0	0	0
019842	Thiosulfate	10	3	100	2	2	0
019842	Thiosulfate	25	3	100	0	0	0
019842	Thiosulfate	50	3	100	0	0	0
019842	Thiosulfate	100	3	100	0	0	0
019855	EDTA	10	3	100	5	4	4
019855	EDTA	25	3	100	0	0	0
019855	EDTA	50	3	100	0	0	0
019855	EDTA	100	3	100	0	0	0
019867	Filtered	10	3	100	0	0	0
019867	Filtered	25	3	100	0	0	0
019867	Filtered	50	3	100	0	0	0
019867	Filtered	100	3	100	0	0	0
019880	Oasis	10	3	100	0	0	0
019880	Oasis	25	3	100	0	0	0
019880	Oasis	50	3	100	0	0	0
019880	Oasis	100	3	100	0	0	0
019919	Ulva	10	3	100	25	32	37
019919	Ulva	25	3	100	13	23	19
019919	Ulva	50	3	100	43	29	34
019919	Ulva	100	3	100	1	1	6

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:2 Method: C72SPED Species: *Strongylocentrotus purpuratus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
019821	Untreated	10	3	100	2	13	15
019821	Untreated	25	3	100	0	6	6
019821	Untreated	50	3	100	0	0	0
019821	Untreated	100	3	100	0	0	0
019834	Thiosulfate	10	3	100	34	28	26
019834	Thiosulfate	25	3	100	19	16	18
019834	Thiosulfate	50	3	100	0	0	0
019834	Thiosulfate	100	3	100	0	0	0
019847	EDTA	10	3	100	60	53	58
019847	EDTA	25	3	100	29	30	26
019847	EDTA	50	3	100	0	0	0
019847	EDTA	100	3	100	0	0	0
019860	Filtered	10	3	100	55	54	58
019860	Filtered	25	3	100	17	20	17
019860	Filtered	50	3	100	0	0	0
019860	Filtered	100	3	100	0	0	0
019872	Oasis	10	3	100	30	28	31
019872	Oasis	25	3	100	3	4	5
019872	Oasis	50	3	100	0	0	0
019872	Oasis	100	3	100	0	0	0
019911	Ulva	10	3	100	61	43	54
019911	Ulva	25	3	100	44	38	42
019911	Ulva	50	3	100	40	42	50
019911	Ulva	100	3	100	59	53	52

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:3 Method: C72SPED Species: *Strongylocentrotus purpuratus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
019822	Untreated	10	3	100	1	5	1
019822	Untreated	25	3	100	0	0	0
019822	Untreated	50	3	100	0	0	0
019822	Untreated	100	3	100	0	0	0
019835	Thiosulfate	10	3	100	0	7	11
019835	Thiosulfate	25	3	100	0	0	0
019835	Thiosulfate	50	3	100	0	0	0
019835	Thiosulfate	100	3	100	0	0	0
019848	EDTA	10	3	100	29	22	33
019848	EDTA	25	3	100	0	0	0
019848	EDTA	50	3	100	0	0	0
019848	EDTA	100	3	100	0	0	0
019861	Filtered	10	3	100	1	0	0
019861	Filtered	25	3	100	0	0	0
019861	Filtered	50	3	100	0	0	0
019861	Filtered	100	3	100	0	0	0
019873	Oasis	10	3	100	0	0	0
019873	Oasis	25	3	100	0	0	0
019873	Oasis	50	3	100	0	0	0
019873	Oasis	100	3	100	0	0	0
019912	Ulva	10	3	100	50	58	52
019912	Ulva	25	3	100	52	40	44
019912	Ulva	50	3	100	45	45	46
019912	Ulva	100	3	100	59	53	
019912	Ulva	100	3	48			22

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:4 Method: C72SPED Species: *Strongylocentrotus purpuratus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
019823	Untreated	10	3	100	22	3	38
019823	Untreated	25	3	100	0	0	0
019823	Untreated	50	3	100	0	0	0
019823	Untreated	100	3	100	0	0	0
019836	Thiosulfate	10	3	100	69	61	63
019836	Thiosulfate	25	3	100	6	12	21
019836	Thiosulfate	50	3	100	0	0	0
019836	Thiosulfate	100	3	100	0	0	0
019849	EDTA	10	3	100	55	55	57
019849	EDTA	25	3	100	16	14	11
019849	EDTA	50	3	100	0	0	0
019849	EDTA	100	3	100	0	0	0
019862	Filtered	10	3	100	60	60	53
019862	Filtered	25	3	100	6	6	7
019862	Filtered	50	3	100	0	0	0
019862	Filtered	100	3	100	0	0	0
019874	Oasis	10	3	100	41	42	29
019874	Oasis	25	3	100	3	3	11
019874	Oasis	50	3	100	0	0	0
019874	Oasis	100	3	100	0	0	0
019913	Ulva	10	3	100	49	69	44
019913	Ulva	25	3	100	50	64	59
019913	Ulva	50	3	100	34	56	57
019913	Ulva	100	3	82			22
019913	Ulva	100	3	100	29		
019913	Ulva	100	3	74		20	

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:5 Method: C72SPED Species: *Strongylocentrotus purpuratus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
019824	Untreated	10	3	100	36	29	28
019824	Untreated	25	3	100	0	0	0
019824	Untreated	50	3	100	0	0	0
019824	Untreated	100	3	100	0	0	0
019837	Thiosulfate	10	3	100	64	69	70
019837	Thiosulfate	25	3	100	0	0	0
019837	Thiosulfate	50	3	100	0	0	0
019837	Thiosulfate	100	3	100	0	0	0
019850	EDTA	10	3	100	29	30	37
019850	EDTA	25	3	100	7	6	0
019850	EDTA	50	3	100	0	0	0
019850	EDTA	100	3	100	0	0	0
019863	Filtered	10	3	100	58	56	63
019863	Filtered	25	3	100	0	0	0
019863	Filtered	50	3	100	0	0	0
019863	Filtered	100	3	100	0	0	0
019875	Oasis	10	3	100	26	20	25
019875	Oasis	25	3	100	3	0	1
019875	Oasis	50	3	100	0	0	0
019875	Oasis	100	3	100	0	0	0
019914	Ulva	10	3	100	48	58	61
019914	Ulva	25	3	100	40	54	55
019914	Ulva	50	3	100	23	41	43
019914	Ulva	100	3	100	58	50	46

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:6 Method: C72SPED Species: *Strongylocentrotus purpuratus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
019825	Untreated	10	3	100	0	6	6
019825	Untreated	25	3	100	2	22	16
019825	Untreated	50	3	100	4	6	0
019825	Untreated	100	3	100	0	0	0
019838	Thiosulfate	10	3	100	49	55	46
019838	Thiosulfate	25	3	100	62	58	50
019838	Thiosulfate	50	3	100	37	32	31
019838	Thiosulfate	100	3	100	0	0	0
019851	EDTA	10	3	100	49	44	52
019851	EDTA	25	3	100	41	48	43
019851	EDTA	50	3	100	29	30	33
019851	EDTA	100	3	100	22	7	12
019864	Filtered	10	3	100	65	58	58
019864	Filtered	25	3	100	56	63	57
019864	Filtered	50	3	100	29	20	16
019864	Filtered	100	3	100	0	0	0
019876	Oasis	10	3	100	34	34	44
019876	Oasis	25	3	100	34	35	28
019876	Oasis	50	3	100	23	23	18
019876	Oasis	100	3	100	5	0	0
019915	Ulva	10	3	100	51	49	43
019915	Ulva	25	3	100	40	29	40
019915	Ulva	50	3	100	65	44	47
019915	Ulva	100	3	100	83	48	59

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:7 Method: C72SPED Species: *Strongylocentrotus purpuratus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
019826	Untreated	10	3	100	0	0	0
019826	Untreated	25	3	100	0	0	0
019826	Untreated	50	3	100	0	0	0
019826	Untreated	100	3	100	0	0	0
019839	Thiosulfate	10	3	100	45	40	33
019839	Thiosulfate	25	3	100	0	0	0
019839	Thiosulfate	50	3	100	1	0	0
019839	Thiosulfate	100	3	100	0	0	
019852	EDTA	10	3	100	34	38	37
019852	EDTA	25	3	100	3	2	0
019852	EDTA	50	3	100	0	0	0
019852	EDTA	100	3	100	0	0	
019877	Oasis	10	3	100	32	30	30
019877	Oasis	25	3	100	4	0	2
019877	Oasis	50	3	100	0	0	0
019877	Oasis	100	3	100	0	0	0
019916	Ulva	10	3	100	35	48	46
019916	Ulva	25	3	100	26	32	36
019916	Ulva	50	3	100	12	50	26
019916	Ulva	100	3	100	39		

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:8 Method: C72SPED Species: *Strongylocentrotus purpuratus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
019827	Untreated	10	3	100	0	0	0
019827	Untreated	25	3	100	0	0	0
019827	Untreated	50	3	100	0	0	0
019827	Untreated	100	3	100	0	0	0
019840	Thiosulfate	10	3	100	0	0	0
019840	Thiosulfate	25	3	100	0	0	0
019840	Thiosulfate	50	3	100	0	0	0
019840	Thiosulfate	100	3	100	0	0	0
019853	EDTA	10	3	100	0	0	2
019853	EDTA	25	3	100	0	0	0
019853	EDTA	50	3	100	0	0	0
019853	EDTA	100	3	100	0	0	0
019865	Filtered	10	3	100		0	0
019865	Filtered	25	3	100	0	0	0
019878	Oasis	10	3	100	0	0	1
019878	Oasis	25	3	100	0	0	0
019878	Oasis	50	3	100	0	0	0
019878	Oasis	100	3	100	0	0	0
019917	Ulva	10	3	100	48	38	38
019917	Ulva	25	3	100	44	29	38
019917	Ulva	50	3	100	40		
019917	Ulva	100	3	100	39	23	31

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: HP:9 Method: C72SPED Species: *Strongylocentrotus purpuratus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
019828	Untreated	10	3	100	1	5	1
019828	Untreated	25	3	100	0	0	0
019828	Untreated	50	3	100	0	0	0
019828	Untreated	100	3	100	0	0	0
019841	Thiosulfate	10	3	100	55	50	48
019841	Thiosulfate	25	3	100	0	0	1
019841	Thiosulfate	50	3	100	0	0	0
019841	Thiosulfate	100	3	100	0	0	0
019854	EDTA	10	3	100	40	34	35
019854	EDTA	25	3	100	2	6	2
019854	EDTA	50	3	100	0	0	0
019854	EDTA	100	3	100	0	0	0
019866	Filtered	10	3	100	42	48	38
019866	Filtered	25	3	100	0	0	0
019866	Filtered	50	3	100	0	0	0
019866	Filtered	100	3	100	0	0	0
019879	Oasis	10	3	100	31	33	35
019879	Oasis	25	3	100	0	0	0
019879	Oasis	50	3	100	0	0	0
019879	Oasis	100	3	100	0	0	0
019918	Ulva	10	3	100	49	42	38
019918	Ulva	25	3	100	41	46	38
019918	Ulva	50	3	100	48	46	35
019918	Ulva	100	3	100	46	34	48

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: REF Method: C72SPED Species: *Strongylocentrotus purpuratus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
019830	Untreated	10	3	100		5	0
019830	Untreated	10	3	60	7		
019830	Untreated	25	3	100	24	14	3
019830	Untreated	50	3	100	0	0	7
019830	Untreated	100	3	100	0	0	0
019843	Thiosulfate	10	3	100	43	48	40
019843	Thiosulfate	25	3	100	35	36	30
019843	Thiosulfate	50	3	100	11	4	13
019843	Thiosulfate	100	3	100	0	0	0
019856	EDTA	10	3	100	33	37	36
019856	EDTA	25	3	100	34	35	35
019856	EDTA	50	3	100	5	1	0
019856	EDTA	100	3	100	0	0	0
019868	Filtered	10	3	100	59	65	61
019868	Filtered	25	3	100	48	47	51
019868	Filtered	50	3	100	7	7	5
019868	Filtered	100	3	100	0	0	0
019881	Oasis	10	3	100	27	28	32
019881	Oasis	25	3	100	15	22	24
019881	Oasis	50	3	100	0	9	4
019881	Oasis	100	3	100	0	0	0
019920	Ulva	10	3	100	54	48	45
019920	Ulva	25	3	100	54	38	35
019920	Ulva	50	3	100	53	22	37
019920	Ulva	100	3	100		37	34
019920	Ulva	100	3	78	40		

Toxicity Detail Report

Science Applications International Corp
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Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunters Pt TIE

Sample: Spike Method: C72SPED Species: *Strongylocentrotus purpuratus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
019819	Untreated	10	3	100	0	0	0
019819	Untreated	25	3	100	0	0	0
019819	Untreated	50	3	100	0	0	0
019819	Untreated	100	3	100	0	0	0
019832	Thiosulfate	10	3	100	10	13	2
019832	Thiosulfate	25	3	100	0	0	0
019832	Thiosulfate	50	3	100	0	0	0
019832	Thiosulfate	100	3	100	0	0	0
019845	EDTA	10	3	100	49	58	67
019845	EDTA	25	3	100	45	44	39
019845	EDTA	50	3	100	5	4	8
019845	EDTA	100	3	100	0	0	1
019858	Filtered	10	3	100	26	23	28
019858	Filtered	25	3	100	18	8	20
019858	Filtered	50	3	100	4	6	3
019858	Filtered	100	3	100	0	1	1
019870	Oasis	10	3	100	15	21	20
019870	Oasis	25	3	100	4	7	6
019870	Oasis	50	3	100	1	0	0
019870	Oasis	100	3	100	0	0	0
019909	Ulva	10	3	100	63	50	53
019909	Ulva	25	3	100	35	59	48
019909	Ulva	50	3	100	46	53	55
019909	Ulva	100	3	100	57	56	66

Toxicity Detail Report

Science Applications International Corp	Date:	8/3/01
221 Third Street	Project:	01025
	SDG	5254
Newport, RI 02840	Site:	Hunters Pt TIE

Submitted By: _____

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: Control Method: C72DES Species: *Dendraster excentricus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
020127	Untreated	100	3	100	97	97	93
020132	Thiosulfate	100	3	100	91	93	96
020137	EDTA	100	3	100	92	93	94
020142	Filtered	100	3	100	93	86	92
020147	Oasis	100	3	100	93	96	87
020157	pH-High	100	3	100	95	93	94
020152	Ulva	100	3	100	55	63	63
020162	Ulva 1st Ulva	100	3	100	94	90	93
020167	Ulva 1st Thiosu	100	3	100	89	94	86
020172	Ulva 1st EDTA	100	3	100	97	91	97

273 Commerce Street, Williston, VT 05495 Tel: 802 860 1638 Fax: 802 [illegible]

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: HP:4 (2) Method: C72DES Species: *Dendraster excentricus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
020129	Untreated	1	3	100	97	92	95
020129	Untreated	10	3	100	94	96	97
020129	Untreated	50	3	100	1	2	1
020129	Untreated	100	3	100	1	0	1
020134	Thiosulfate	1	3	100	96	95	97
020134	Thiosulfate	10	3	100	93	95	94
020134	Thiosulfate	50	3	100	0	0	0
020134	Thiosulfate	100	3	100	0	0	0
020139	EDTA	1	3	100	89	97	99
020139	EDTA	10	3	100	91	99	95
020139	EDTA	50	3	87	2		
020139	EDTA	50	3	100		0	0
020139	EDTA	100	3	100	0	0	0
020144	Filtered	1	3	100	94	97	93
020144	Filtered	10	3	100	95	93	92
020144	Filtered	50	3	100		0	0
020144	Filtered	50	3	89	3		
020144	Filtered	100	3	100	0	0	0
020149	Oasis	1	3	100	93	94	86
020149	Oasis	10	3	100	82	92	78
020149	Oasis	50	3	100	0	0	0

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: HP:4 (2) Method: C72DES Species: *Dendraster excentricus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
020149	Oasis	100	3	100	0	1	0
020159	pH-High	1	3	100	96	93	88
020159	pH-High	10	3	100	92	90	89
020159	pH-High	50	3	100	0	0	0
020159	pH-High	100	3	100	0	0	0
020154	Ulva	1	3	100	92	86	90
020154	Ulva	10	3	100	92	91	90
020154	Ulva	50	3	100	83	84	79
020154	Ulva	100	3	100	78	84	83
020164	Ulva 1st Ulva	1	3	100	93	91	89
020164	Ulva 1st Ulva	10	3	100	97	93	95
020164	Ulva 1st Ulva	50	3	100	92	91	90
020164	Ulva 1st Ulva	100	3	100	55	50	41
020169	Ulva 1st Thiosu	1	3	100	91	95	95
020169	Ulva 1st Thiosu	10	3	100	91	95	93
020169	Ulva 1st Thiosu	50	3	100	96	95	86
020169	Ulva 1st Thiosu	100	3	100	68	62	67
020174	Ulva 1st EDTA	1	3	100	93	94	95
020174	Ulva 1st EDTA	10	3	100	93	88	92
020174	Ulva 1st EDTA	50	3	100	92	92	97
020174	Ulva 1st EDTA	100	3	100	73	76	75

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: HP:5 (2) Method: C72DES Species: *Dendraster excentricus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
020130	Untreated	1	3	100	97	96	94
020130	Untreated	10	3	100	29	41	26
020130	Untreated	50	3	100	0	0	0
020130	Untreated	100	3	100	0	0	0
020135	Thiosulfate	1	3	100	95	92	95
020135	Thiosulfate	10	3	100	34	30	36
020135	Thiosulfate	50	3	100	0	0	0
020135	Thiosulfate	100	3	100	0	0	0
020140	EDTA	1	3	100	98	100	95
020140	EDTA	10	3	100	67	62	52
020140	EDTA	50	3	100	0	0	0
020140	EDTA	100	3	100	0	0	0
020145	Filtered	1	3	100	91	90	91
020145	Filtered	10	3	100	62	67	65
020145	Filtered	50	3	100	0	0	0
020145	Filtered	100	3	100	0	0	0
020150	Oasis	1	3	100	88	89	78
020150	Oasis	10	3	100	43	37	33
020150	Oasis	50	3	100	0	0	0
020150	Oasis	100	3	100	0	1	1
020160	pH-High	1	3	100	91	88	89

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: HP:5 (2) Method: C72DES Species: *Dendraster excentricus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
020160	pH-High	10	3	100	54	37	31
020160	pH-High	50	3	100	2	0	0
020160	pH-High	100	3	100	0	0	0
020155	Ulva	1	3	100	88	89	86
020155	Ulva	10	3	100	84	83	84
020155	Ulva	50	3	100	70	67	63
020155	Ulva	100	3	100	0	0	0
020165	Ulva 1st Ulva	1	3	100	96	96	94
020165	Ulva 1st Ulva	10	3	100	91	96	92
020165	Ulva 1st Ulva	50	3	100	2	1	0
020165	Ulva 1st Ulva	100	3	100	0	0	0
020170	Ulva 1st Thiosu	1	3	100	94	88	92
020170	Ulva 1st Thiosu	10	3	100	95	95	97
020170	Ulva 1st Thiosu	50	3	100	19	10	13
020170	Ulva 1st Thiosu	100	3	100	0	0	0
020175	Ulva 1st EDTA	1	3	100	93	94	95
020175	Ulva 1st EDTA	10	3	100	93	94	98
020175	Ulva 1st EDTA	50	3	100	5	10	1
020175	Ulva 1st EDTA	100	3	100	0	0	0

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: HP:9 (2) Method: C72DES Species: *Dendraster excentricus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
020131	Untreated	1	3	100	97	95	92
020131	Untreated	10	3	100	8	8	6
020131	Untreated	50	3	100	0	0	0
020131	Untreated	100	3	100		0	0
020136	Thiosulfate	1	3	100	93	94	89
020136	Thiosulfate	10	3	100	17	17	9
020136	Thiosulfate	50	3	100	0	0	0
020136	Thiosulfate	100	3	100	0	0	0
020141	EDTA	1	3	100	94	92	98
020141	EDTA	10	3	100	24	31	36
020141	EDTA	50	3	100	0	0	0
020141	EDTA	100	3	100	0	0	0
020146	Filtered	1	3	100	92	95	88
020146	Filtered	10	3	100	56	55	50
020146	Filtered	50	3	100	0	0	0
020146	Filtered	100	3	100	0	0	0
020151	Oasis	1	3	100	91	88	83
020151	Oasis	10	3	100	19	18	16
020151	Oasis	50	3	100	0	0	0
020151	Oasis	100	3	100	0	0	1
020161	pH-High	1	3	100	93	92	95

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: HP:9 (2) Method: C72DES Species: *Dendraster excentricus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
020161	pH-High	10	3	100	84	85	79
020161	pH-High	50	3	100	0	0	0
020161	pH-High	100	3	100	0	0	0
020156	Ulva	1	3	100	93	89	86
020156	Ulva	10	3	100	79	74	73
020156	Ulva	50	3	100	69	71	67
020156	Ulva	100	3	100	0	0	0
020166	Ulva 1st Ulva	1	3	100	85	89	91
020166	Ulva 1st Ulva	10	3	100	81	90	80
020166	Ulva 1st Ulva	50	3	100	39	63	52
020166	Ulva 1st Ulva	100	3	100	0	0	0
020171	Ulva 1st Thiosu	1	3	100	96	96	97
020171	Ulva 1st Thiosu	10	3	100	92	90	96
020171	Ulva 1st Thiosu	50	3	100	90	91	89
020171	Ulva 1st Thiosu	100	3	100	3	3	2
020176	Ulva 1st EDTA	1	3	100	94	93	87
020176	Ulva 1st EDTA	10	3	100	96	94	94
020176	Ulva 1st EDTA	50	3	100	93	98	96
020176	Ulva 1st EDTA	100	3	100	4	5	7

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: REF (2) Method: C72DES Species: *Dendraster excentricus*

Number	Treatment	Conc(%)	Day	Start	Replicate Normal Development 1	2	3
020128	Untreated	1	3	100	93	95	96
020128	Untreated	10	3	100	98	96	88
020128	Untreated	50	3	100	35	32	23
020128	Untreated	100	3	100	0	0	1
020133	Thiosulfate	1	3	100	93	98	94
020133	Thiosulfate	10	3	100	97	94	91
020133	Thiosulfate	50	3	100	22	34	43
020133	Thiosulfate	100	3	100	0	5	0
020138	EDTA	1	3	100	95	91	97
020138	EDTA	10	3	100	95	96	95
020138	EDTA	50	3	100	87	73	71
020138	EDTA	100	3	100	1	0	0
020143	Filtered	1	3	100	95	92	92
020143	Filtered	10	3	100	97	91	93
020143	Filtered	50	3	100	64	65	77
020143	Filtered	100	3	100	0	0	1
020148	Oasis	1	3	100	93	96	88
020148	Oasis	10	3	100	96	94	94
020148	Oasis	50	3	100	78	54	47
020148	Oasis	100	3	100	0	0	3
020158	pH-High	1	3	100	93	84	93

Toxicity Detail Report

Science Applications International Corp
221 Third Street

Newport, RI 02840

Date: 8/3/01
Project: 01025
SDG 5254
Site: Hunter's Point (2)

Sample: REF (2) Method: C72DES Species: *Dendraster excentricus*

					Replicate Normal Development		
Number	Treatment	Conc(%)	Day	Start	1	2	3
020158	pH-High	10	3	100	90	90	81
020158	pH-High	50	3	100	71	66	49
020158	pH-High	100	3	100	0	1	0
020153	Ulva	1	3	100	86	88	85
020153	Ulva	10	3	100	79	88	86
020153	Ulva	50	3	100	85	78	80
020153	Ulva	100	3	100	54	43	50
020163	Ulva 1st Ulva	1	3	100	90	92	90
020163	Ulva 1st Ulva	10	3	100	86	92	89
020163	Ulva 1st Ulva	50	3	100	85	87	81
020163	Ulva 1st Ulva	100	3	100	62	56	65
020168	Ulva 1st Thiosu	1	3	100	94	93	94
020168	Ulva 1st Thiosu	10	3	100		94	90
020168	Ulva 1st Thiosu	50	3	100	82	80	85
020168	Ulva 1st Thiosu	100	3	100	85	65	65
020173	Ulva 1st EDTA	1	3	100	91	94	87
020173	Ulva 1st EDTA	10	3	100	92	89	84
020173	Ulva 1st EDTA	50	3	100	80	82	74
020173	Ulva 1st EDTA	100	3	100	93	74	74

Submitted By: _____

Supportive Documentation

Chain-Of-Custody

Toxicity Test Methods

Menidia 48 h static acute

Sand Dollar, Dendraster excentricus, 72 Hour Larval Development

West Coast sea urchin 72h embryo development test

Standard Reference Toxicant Control Charts

Available Upon Request

APPENDIX B-2
Toxicity calculations
(Sample pages provided – full document available upon request)

Larval Fish Growth and Survival Test-48 Hr Survival

Start Date:	6/8/01	Test ID:	HP-MUNT-4	Sample ID:	HP4
End Date:	6/10/01	Lab ID:	AQUATEC	Sample Type:	AMB1-Ambient water
Sample Date:		Protocol:	EPAM 87-EPA Marine	Test Species:	MI-Menidia menidia
Comments:	actual organism: M. menidia				

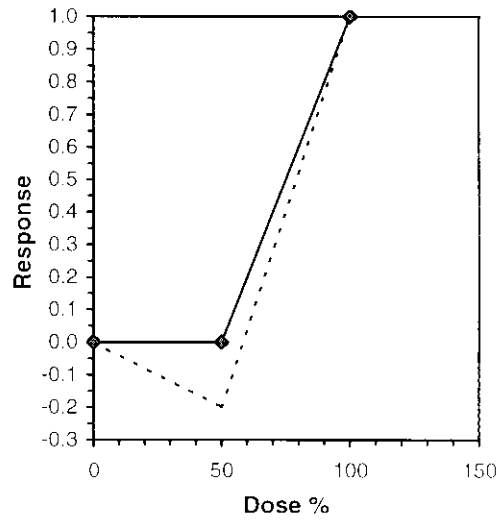
Conc-%	1	2	3
B-Control	1.0000	0.8000	0.6000
50	1.0000	1.0000	
100	0.6000	0.4000	0.4000

			Transform: Arcsin Square Root					Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Mean	N-Mean
B-Control	0.8000	1.0000	1.0135	0.8861	1.1071	11.281	3	0.9167	1.0000
50	1.0000	1.2500	1.0472	1.0472	1.0472	0.000	2	0.9167	1.0000
100	0.4667	0.5833	0.7518	0.6847	0.8861	15.463	3	0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.96734	0.749	0.17461	-0.6988
Equality of variance cannot be confirmed				

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC01	50.500	0.176	51.912	54.500	1.3032
IC05	52.500	0.880	59.559	72.500	1.3032
IC10	55.000	1.760	69.118	95.000	1.3032
IC15	57.500	2.640	78.676	117.500	1.3032
IC20	60.000	3.520	88.235	140.000	1.3032
IC25	62.500	4.399	97.794	162.500	1.3032
IC40	70.000				
IC50	75.000				
IC60	80.000				
IC75	87.500				
IC80	90.000				
IC85	92.500				
IC90	95.000				
IC95	97.500				
IC99	99.500				



Larval Fish Growth and Survival Test-48 Hr Survival

Start Date:	6/8/01	Test ID:	HP-MUNT-4	Sample ID:	HP4
End Date:	6/10/01	Lab ID:	AQUATEC	Sample Type:	AMB1-Ambient water
Sample Date:		Protocol:	EPAM 87-EPA Marine	Test Species:	MI-Menidia menidia
Comments:	actual organism: M. menidia				

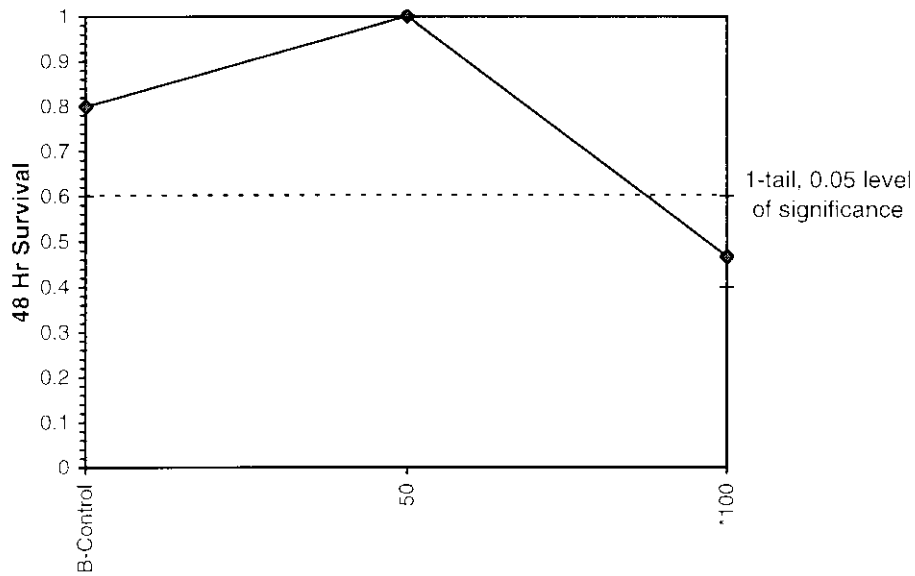
Conc-%	1	2	3
B-Control	1.0000	0.8000	0.6000
50	1.0000	1.0000	
100	0.6000	0.4000	0.4000

			Transform: Arcsin Square Root					1-Tailed		
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
B-Control	0.8000	1.0000	1.0135	0.8861	1.1071	11.281	3			
50	1.0000	1.2500	1.0472	1.0472	1.0472	0.000	2	-0.358	2.440	0.2297
*100	0.4667	0.5833	0.7518	0.6847	0.8861	15.463	3	3.107	2.440	0.2054

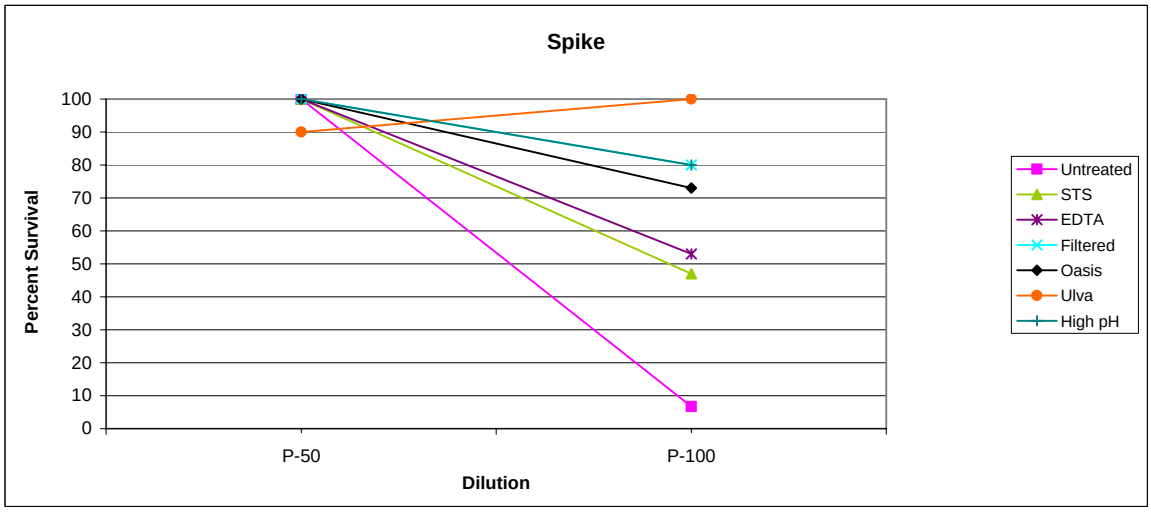
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.96734	0.749	0.17461	-0.6988
Equality of variance cannot be confirmed				

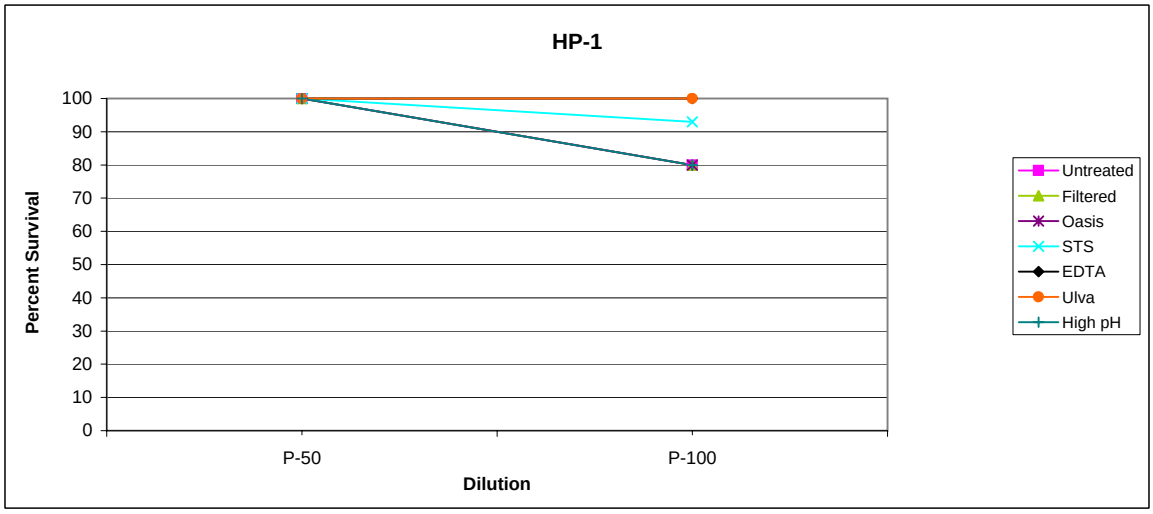
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	50	100	70.7107	2	0.19763	0.27439	0.07165	0.01063	0.03811	2, 5

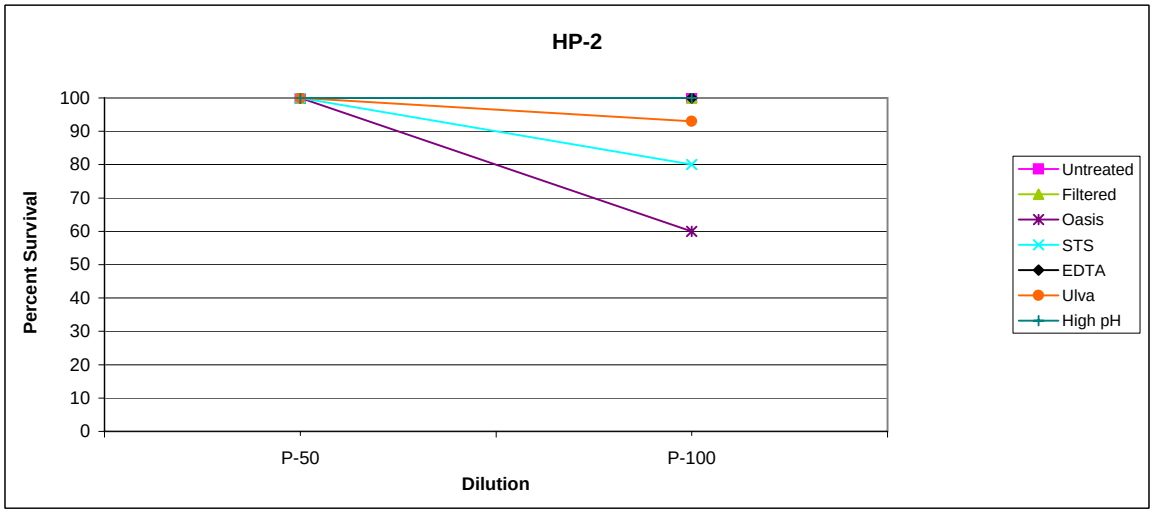
Dose-Response Plot

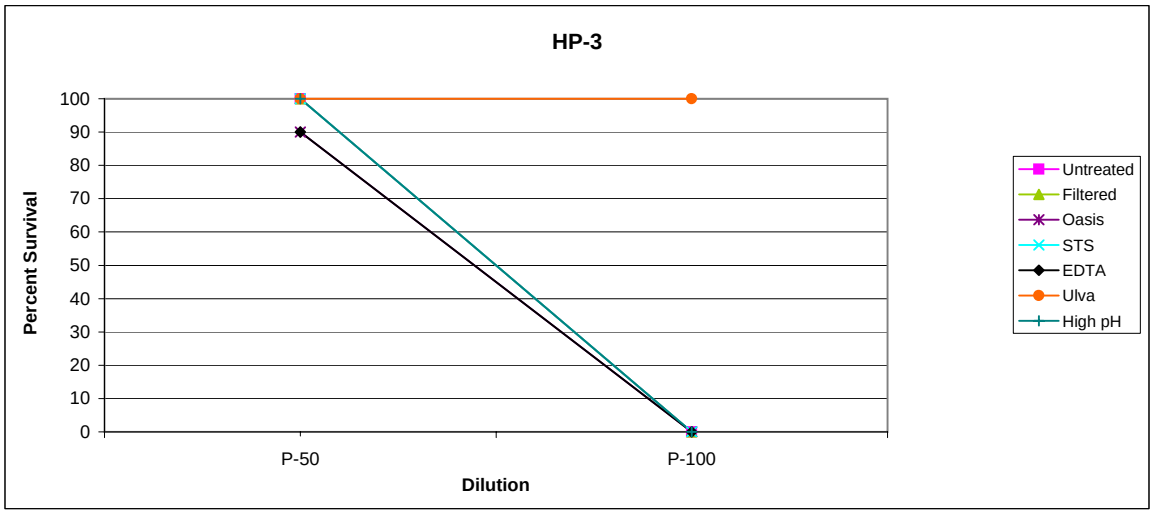


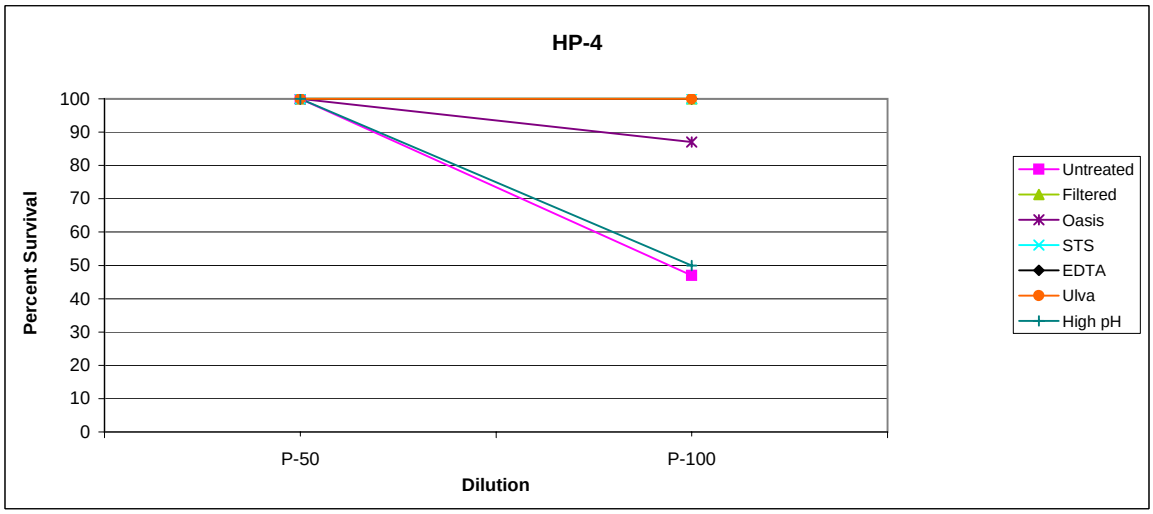
Appendix B-3-1. Plots of percent survival of *Menidia menidia* vs. sample dilution by station for the Hunter's Point TIE study.

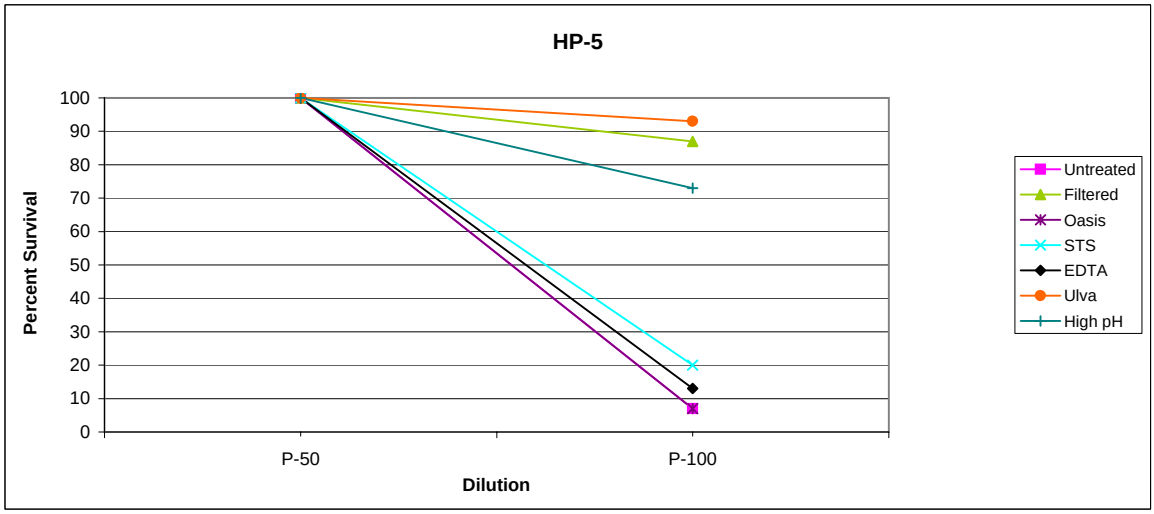


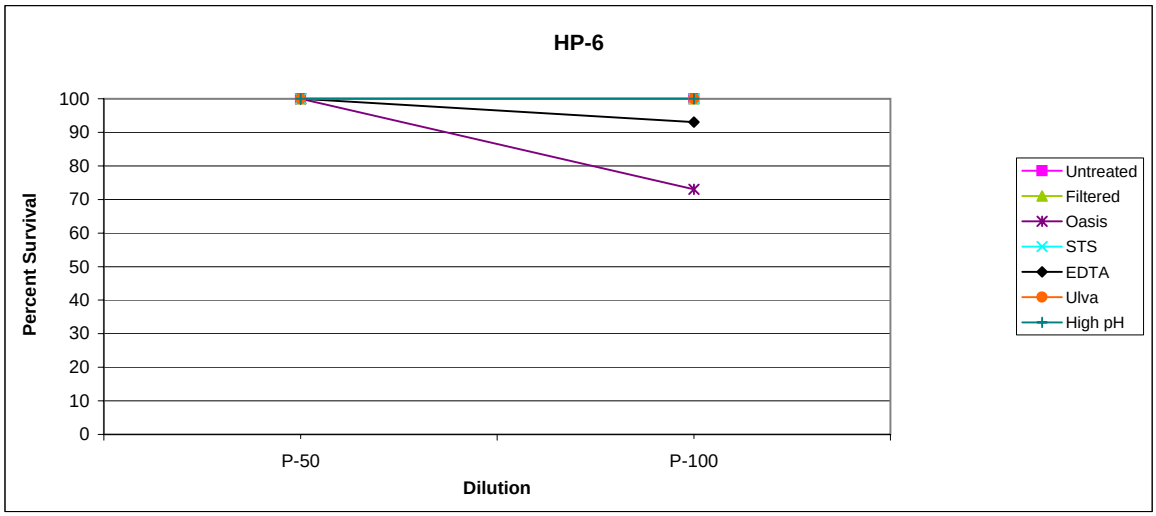


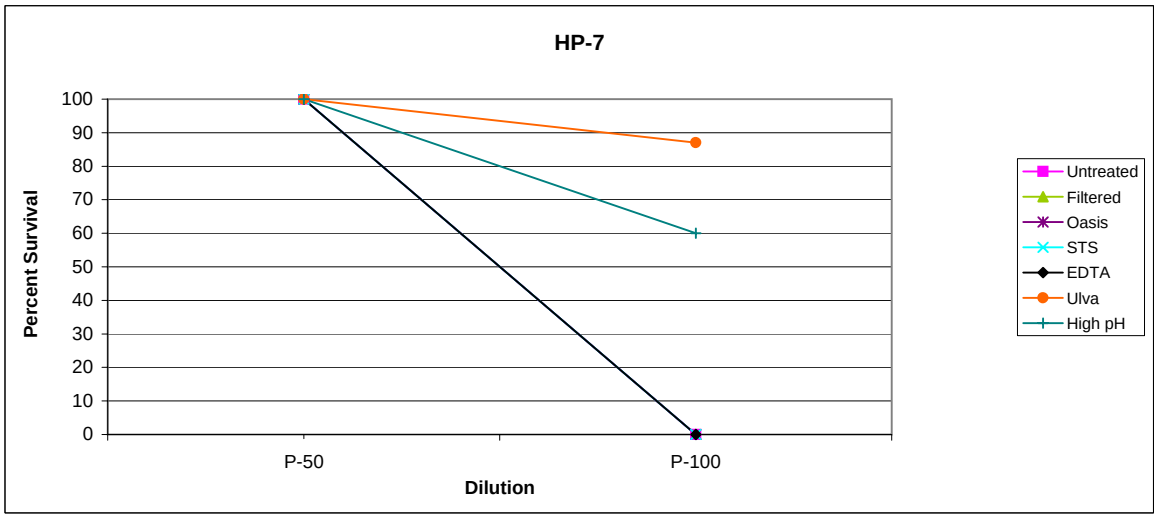


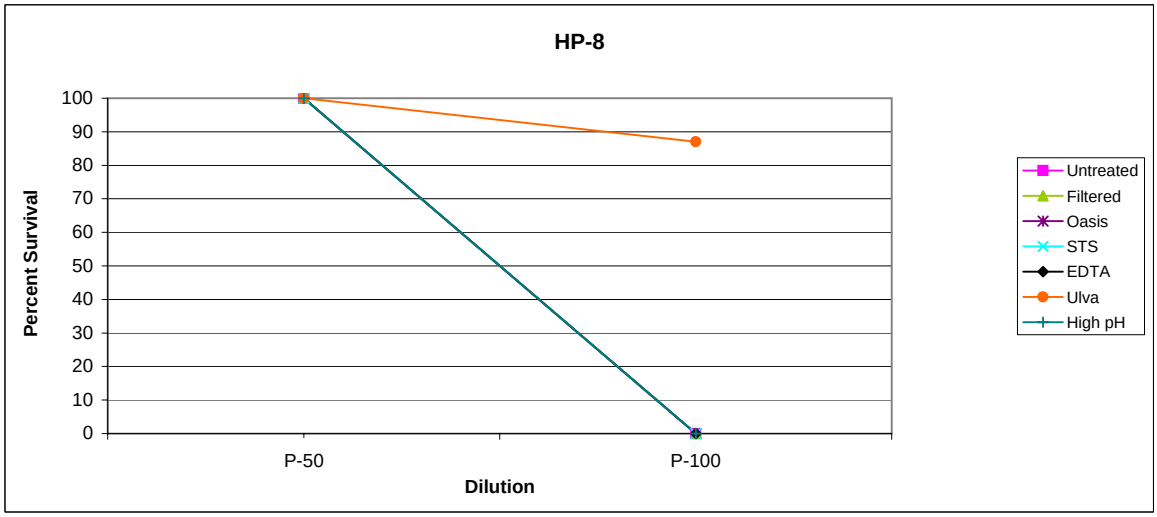

HP-3
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

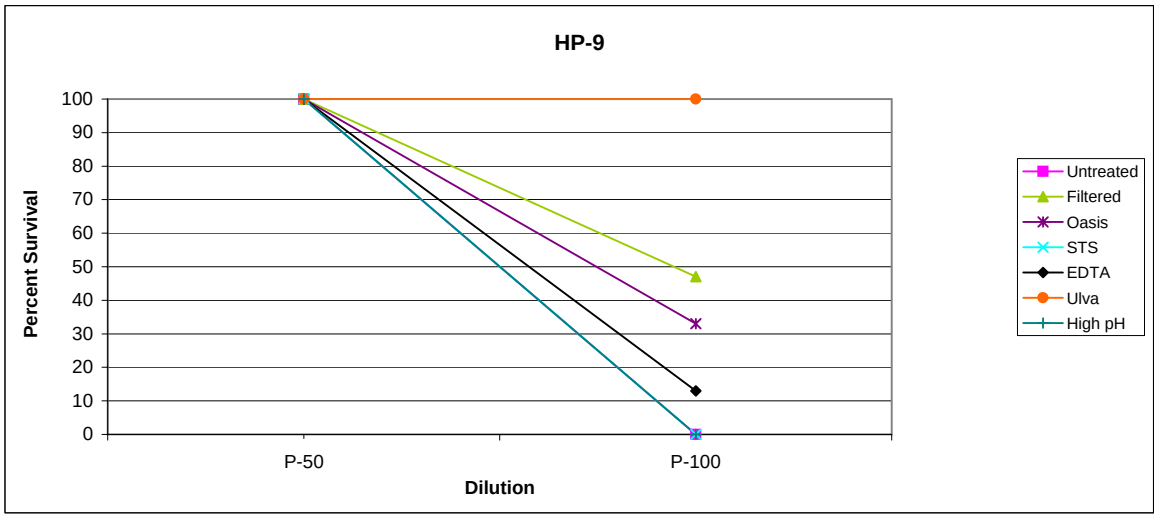

HP-4
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

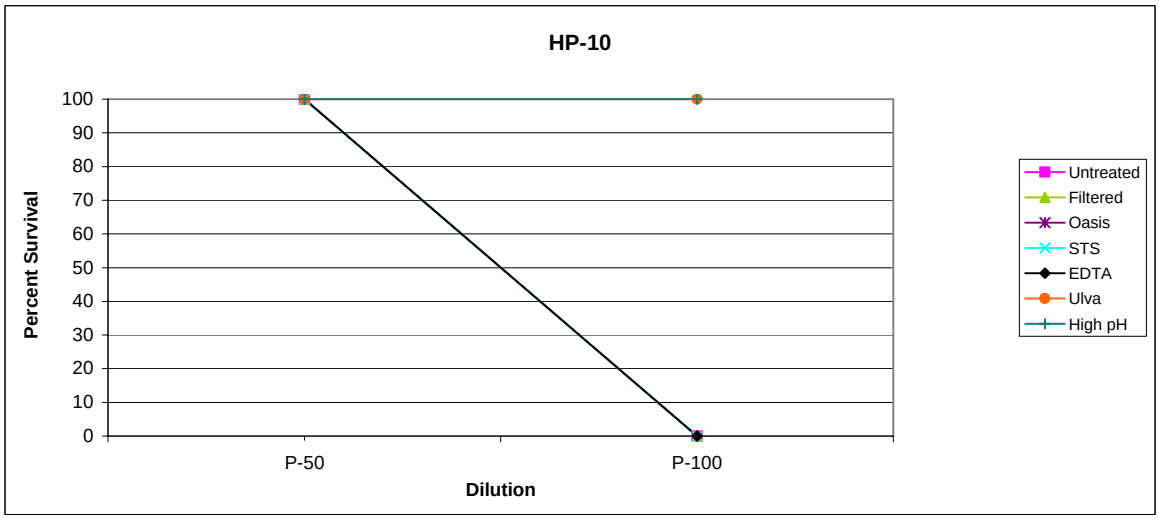

HP-5
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

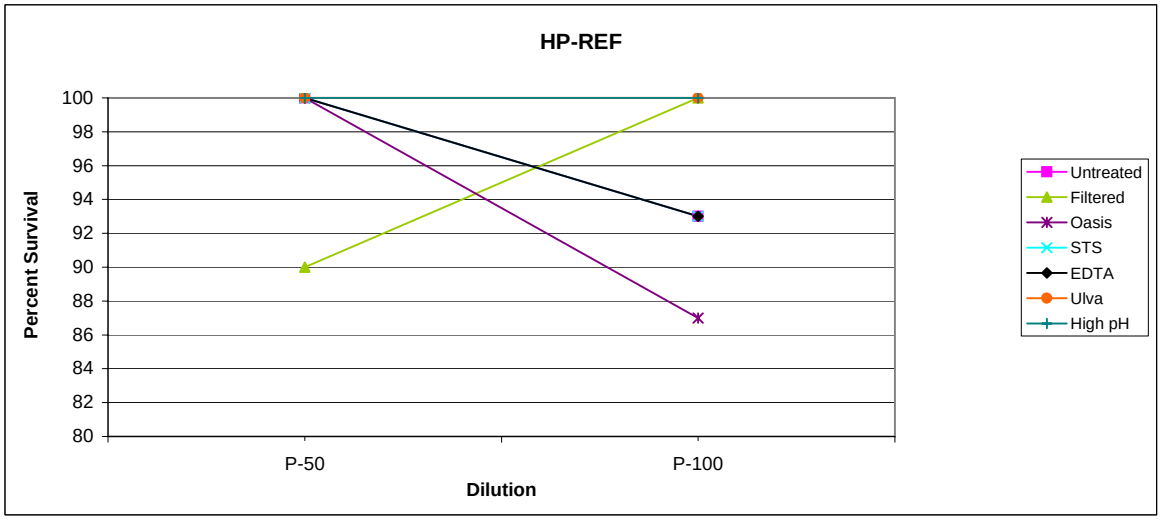

HP-6
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

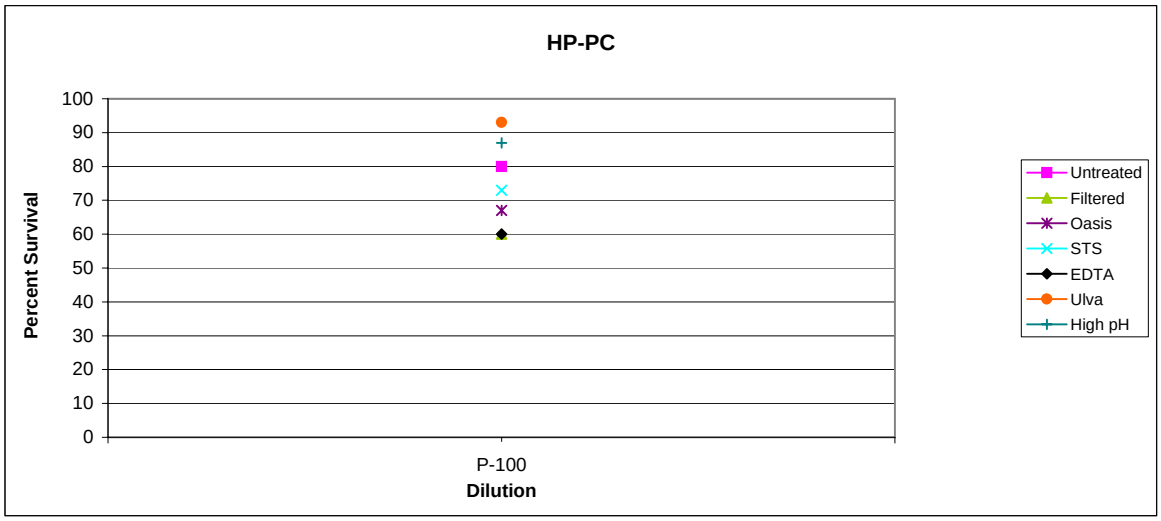

HP-7
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH


HP-8
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

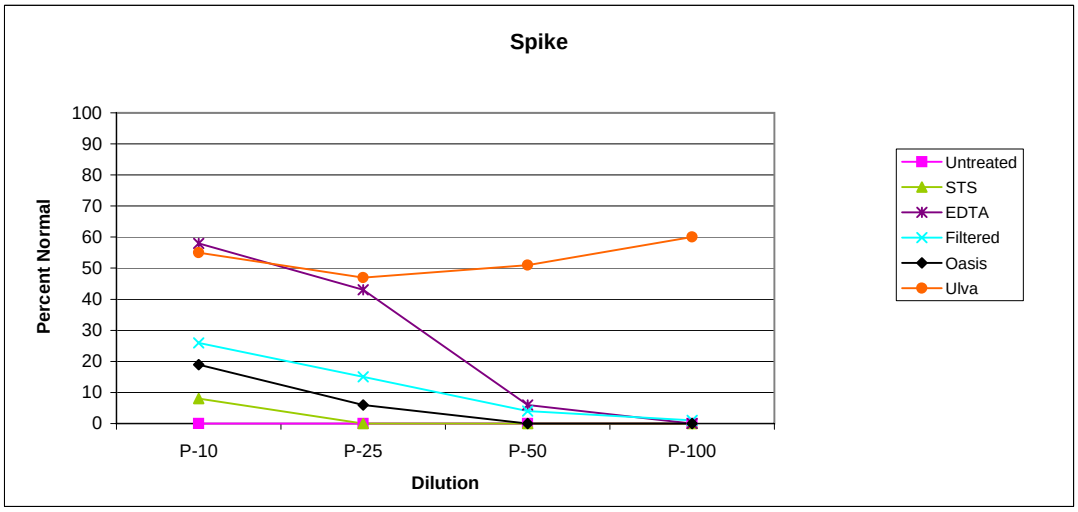

HP-9
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

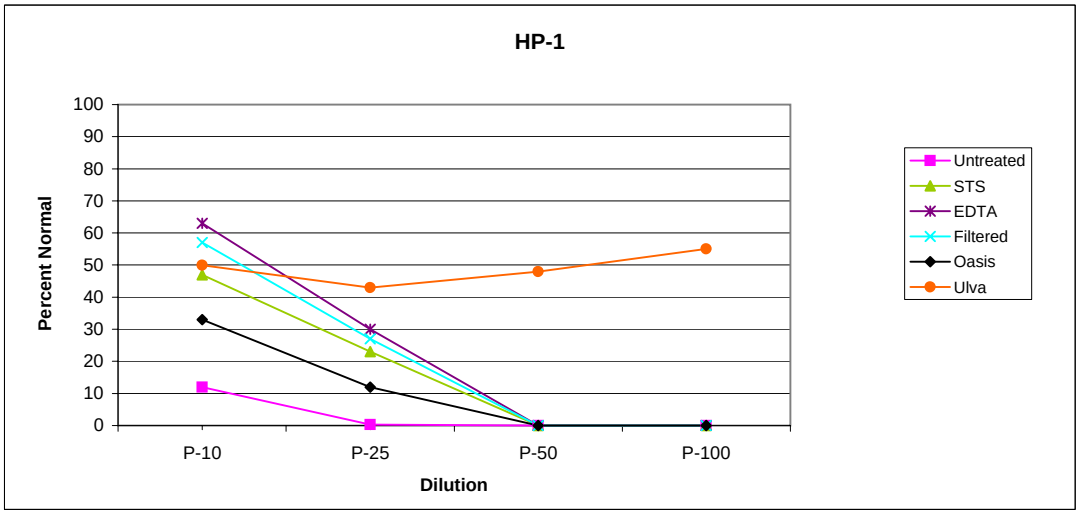

HP-10
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

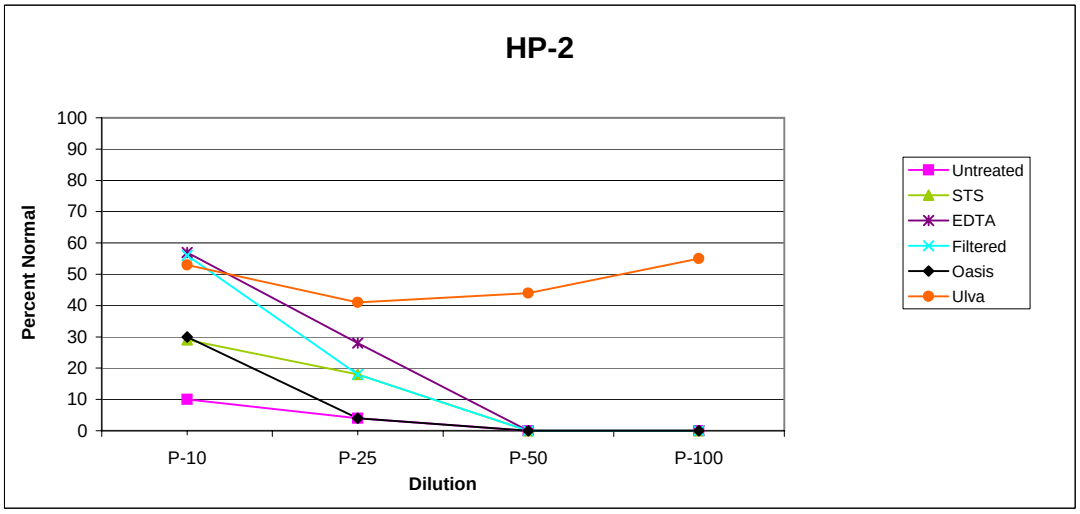

HP-REF
Percent Survival
100
98
96
94
92
90
88
86
84
82
80
P-50
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

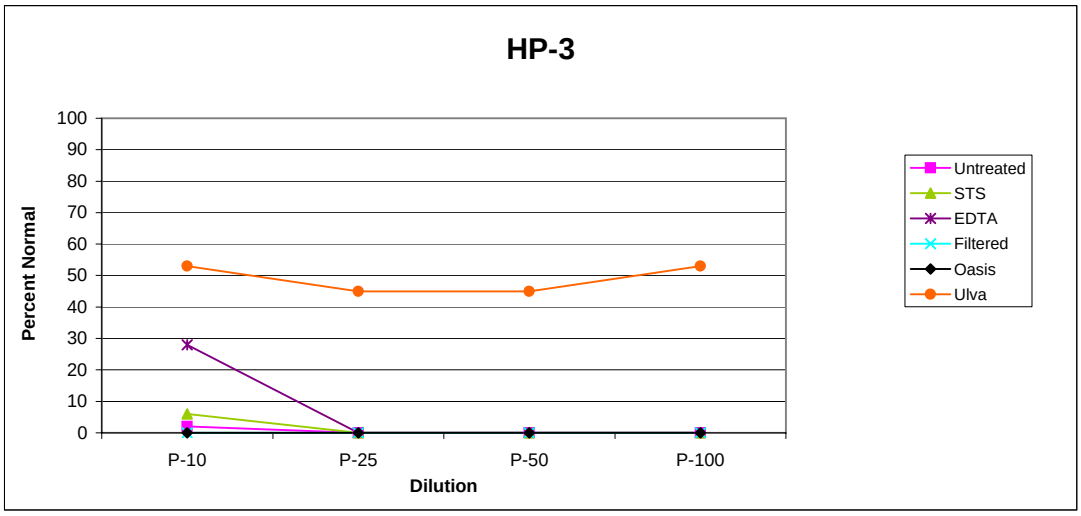

HP-PC
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
P-100
Dilution
Untreated
Filtered
Oasis
STS
EDTA
Ulva
High pH

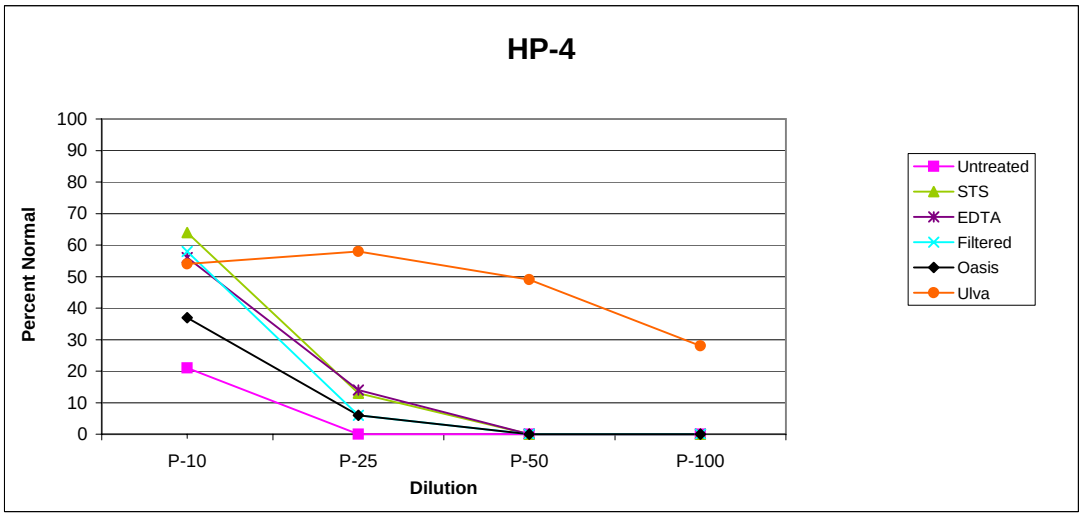
Appendix B-3-2. Plots of percent normal development of *Strongylocentrotus purpuratus* vs. sample dilution by station for the Hunter's Point TIE study.

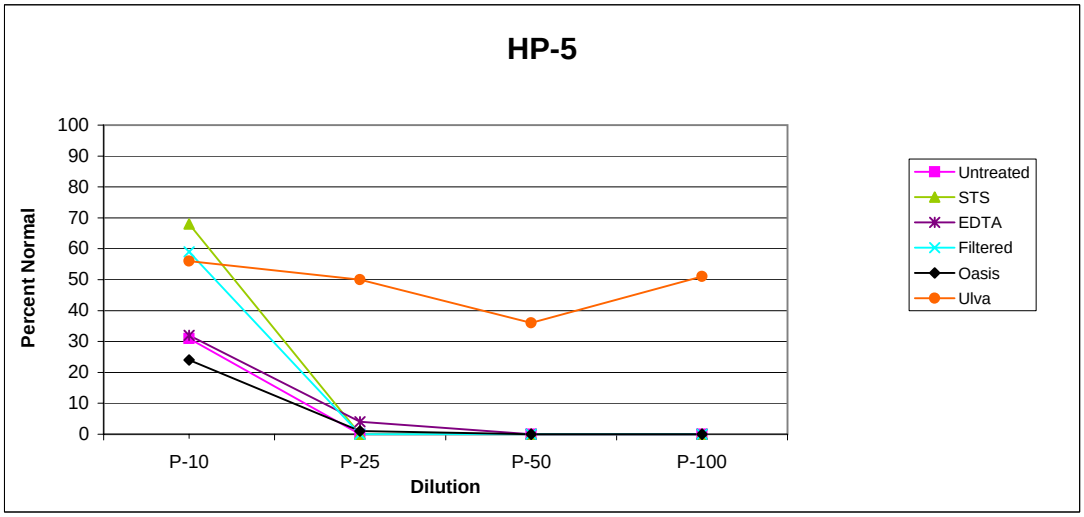


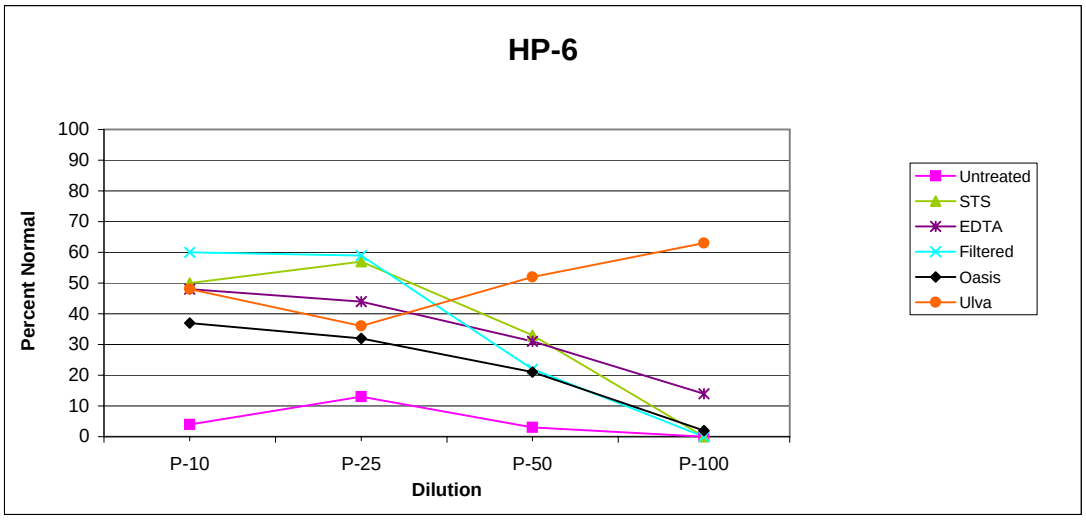


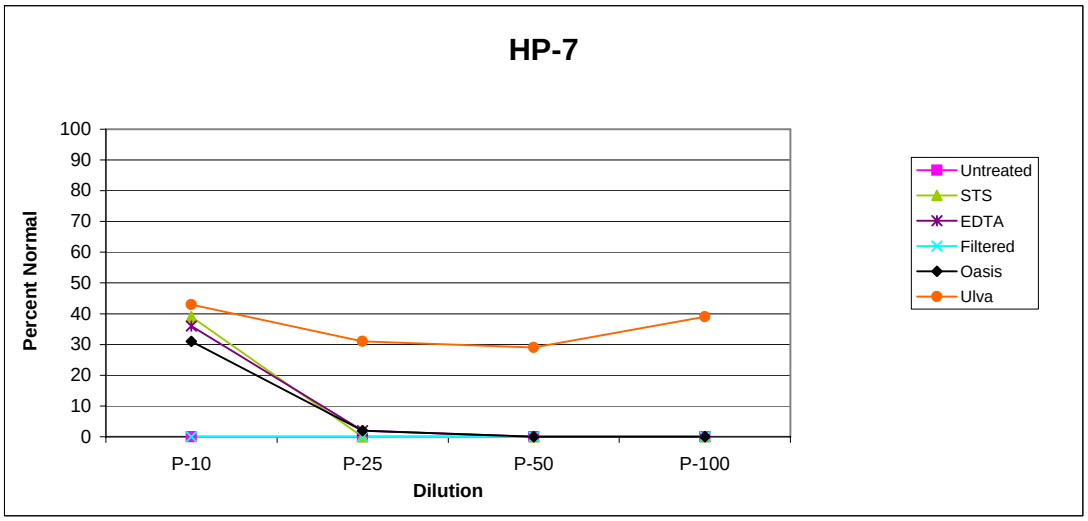


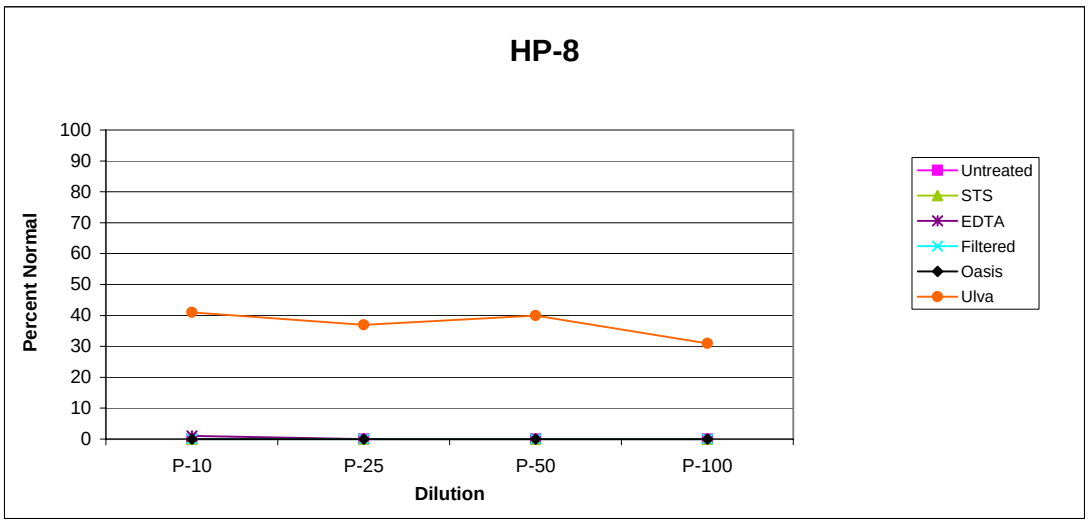

HP-3
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

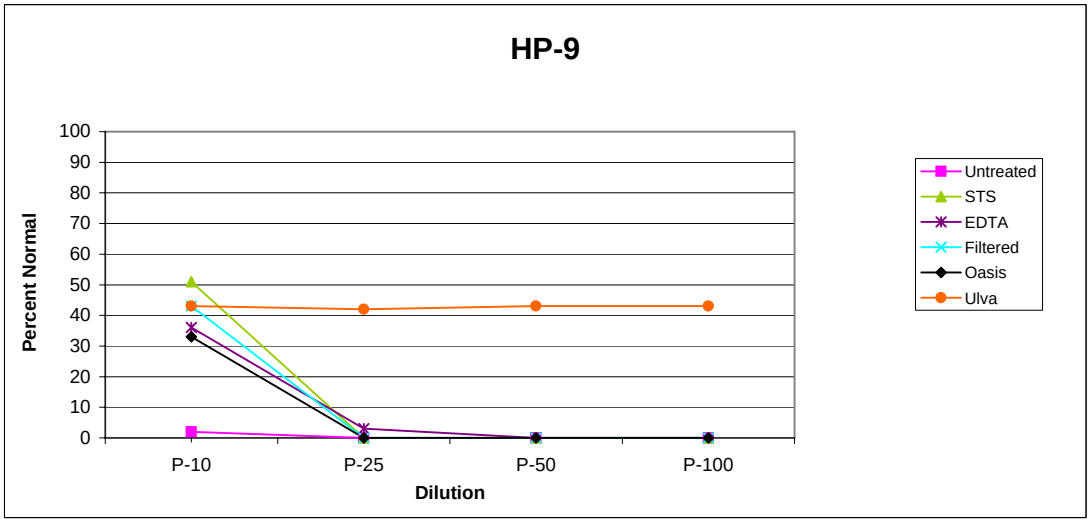

HP-4
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

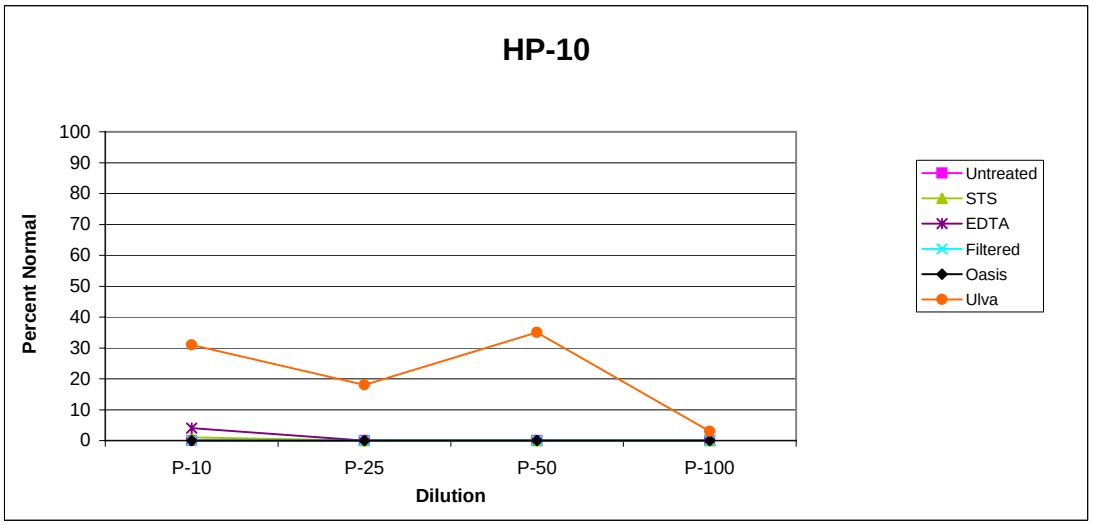

HP-5
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

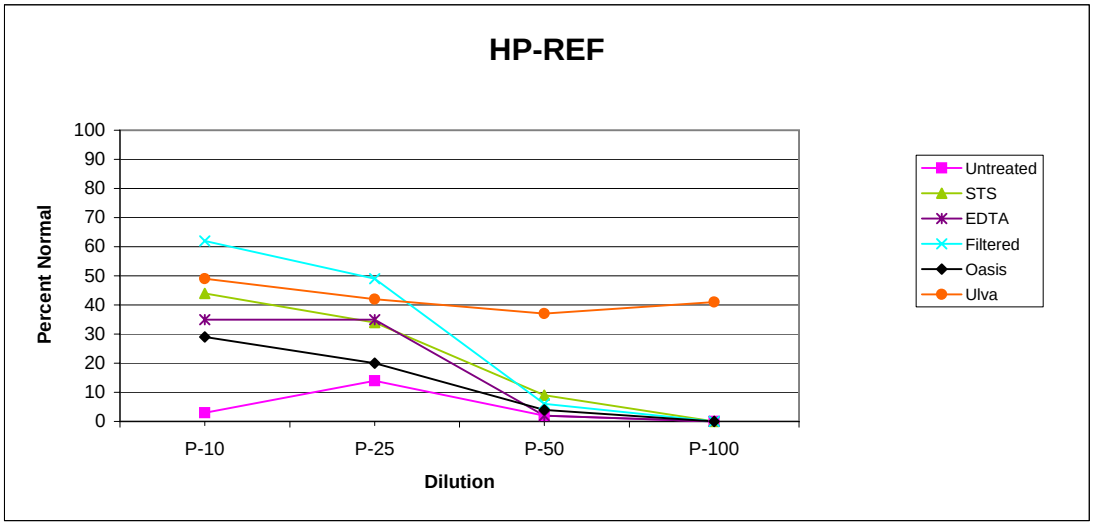

HP-6
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

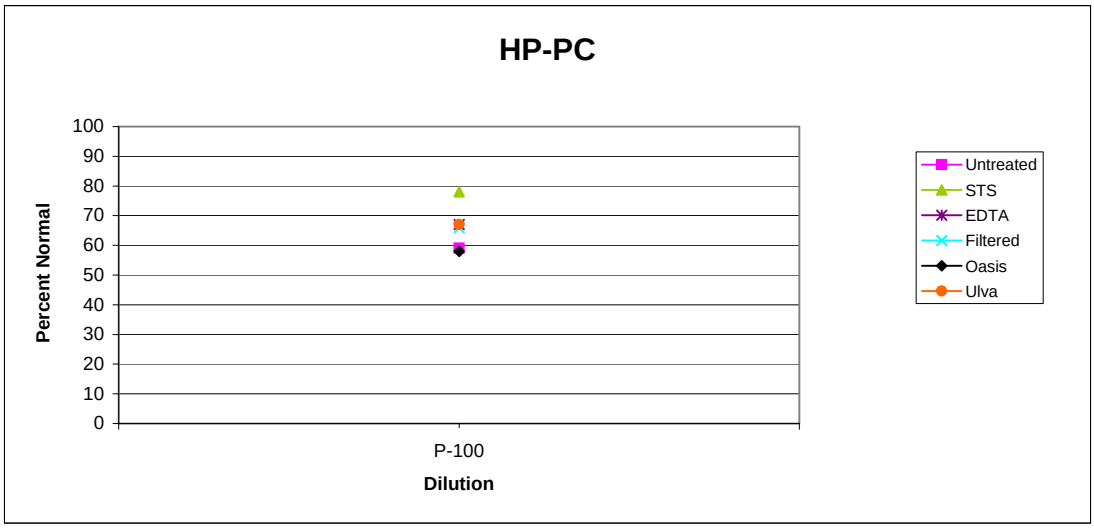

HP-7
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva


HP-8
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

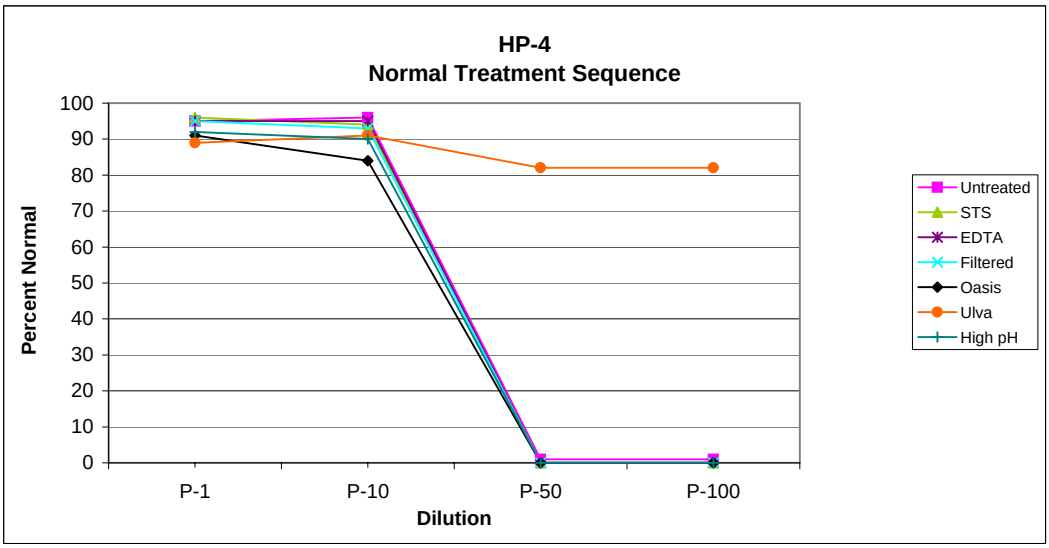

HP-9
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

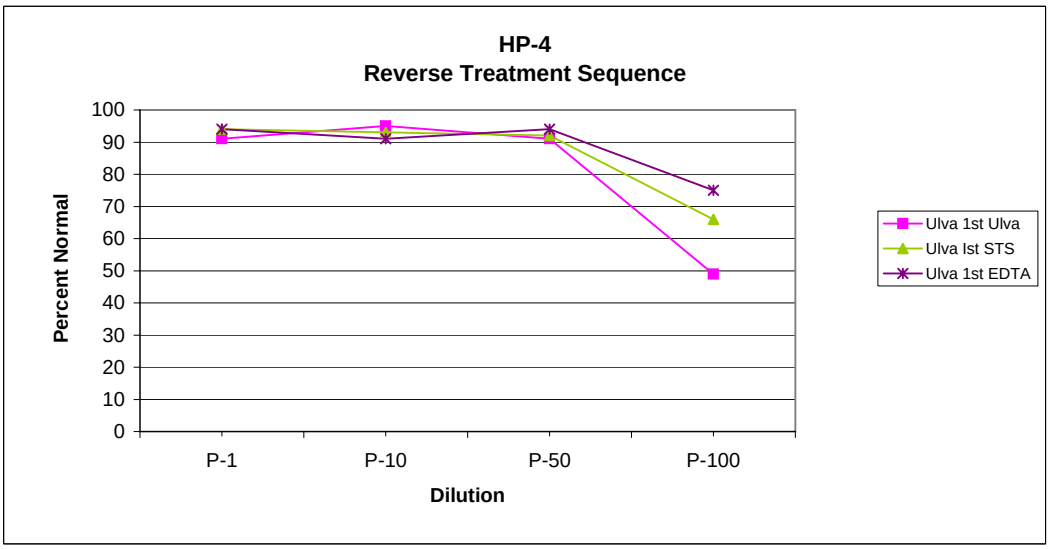

HP-10
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

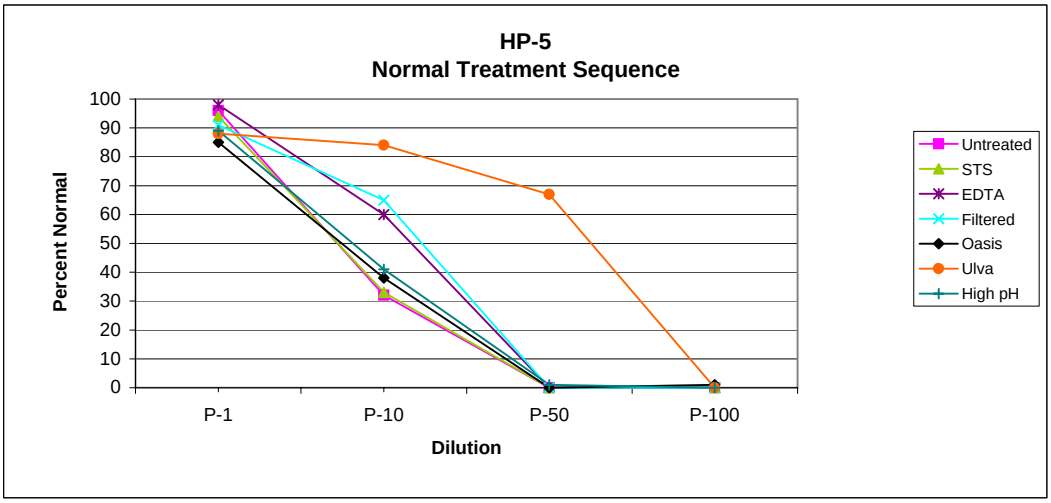

HP-REF
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-10
P-25
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

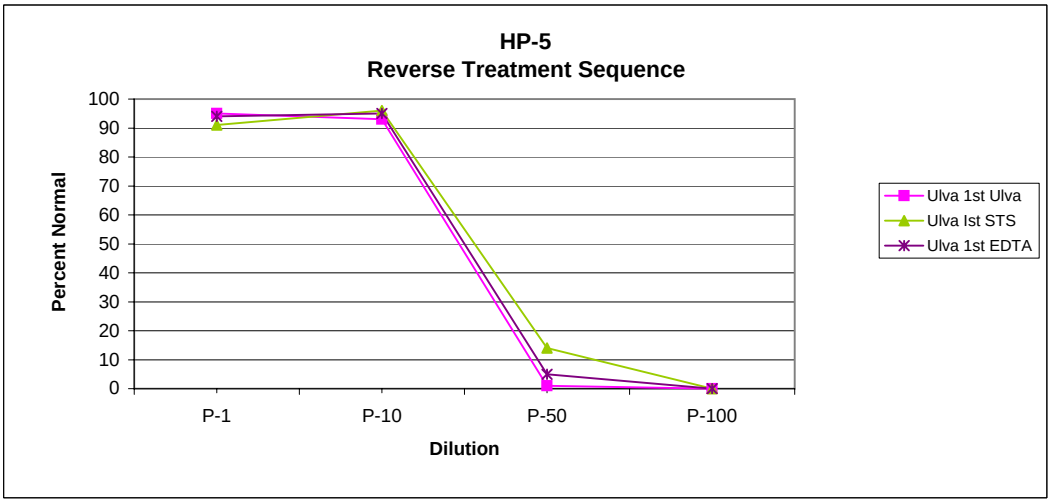

HP-PC
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva

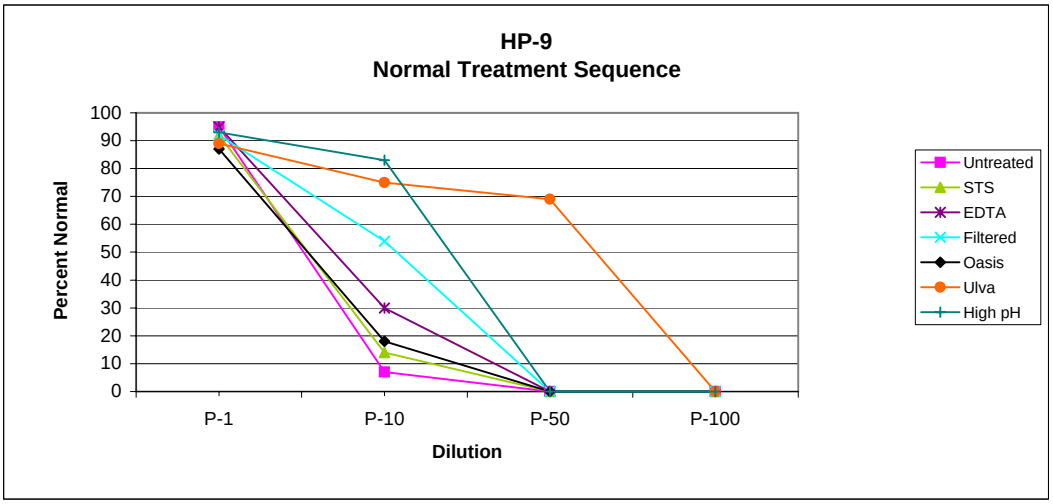
Appendix B-3-3. Plots of percent normal development of *Dendraster excentricus* vs. sample dilution by station for the Hunters Point TIE study.

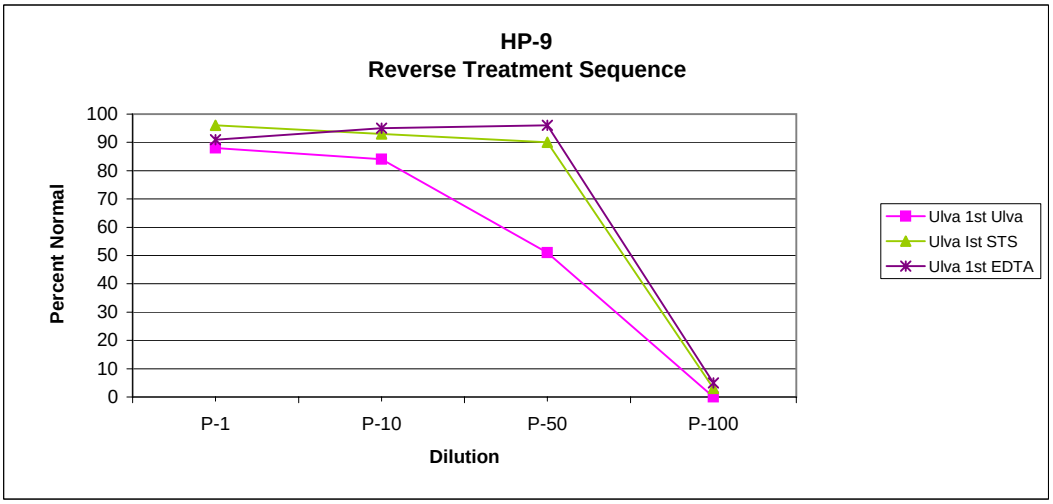


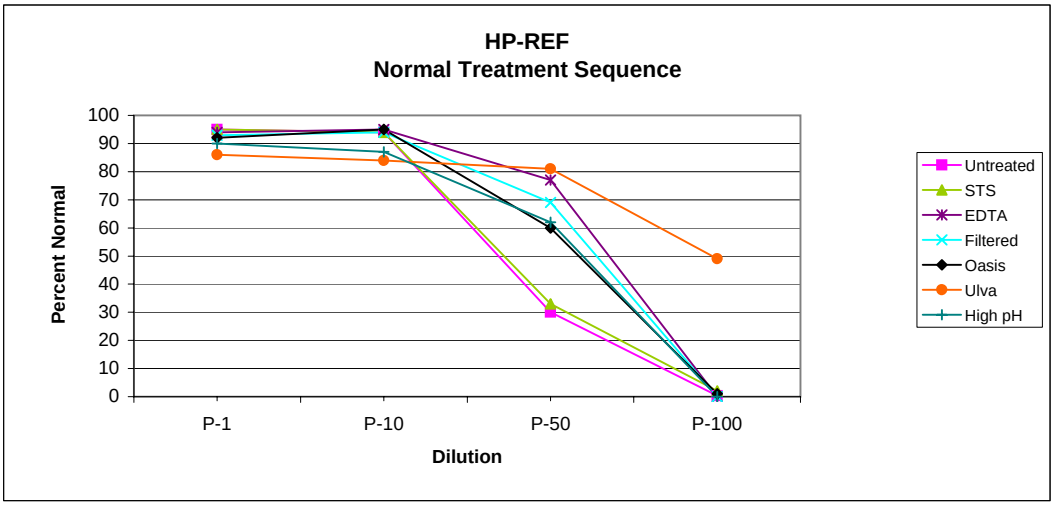


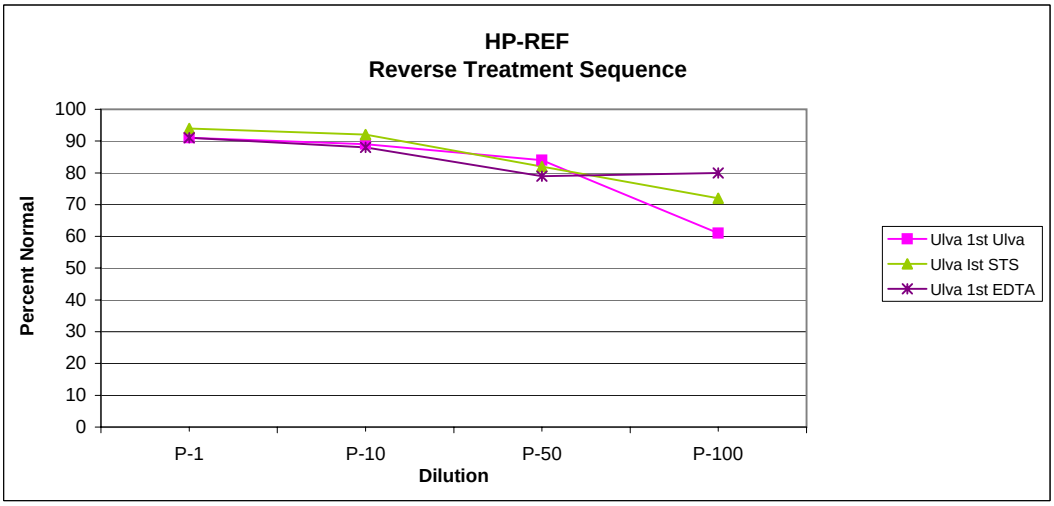

HP-5
Normal Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-1
P-10
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva
High pH

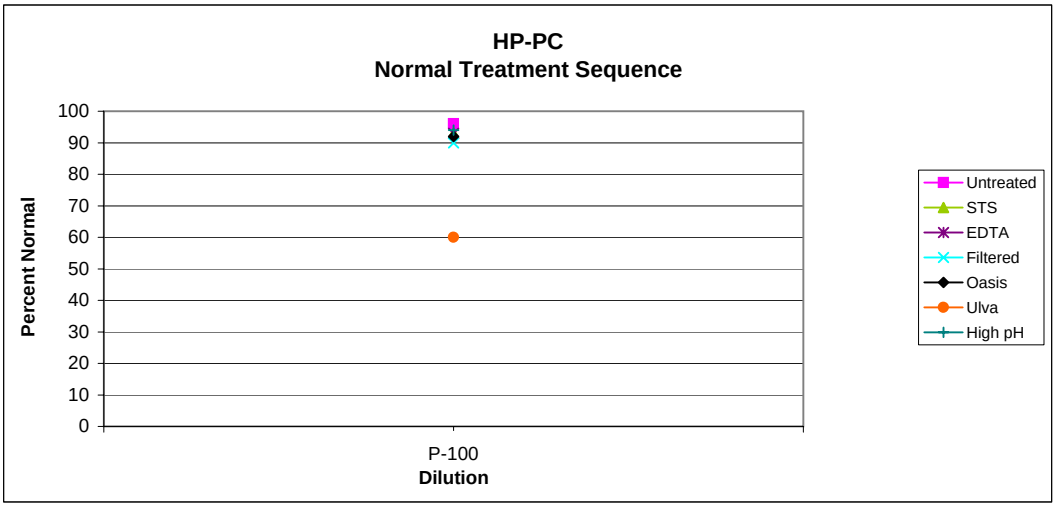

HP-5
Reverse Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-1
P-10
P-50
P-100
Dilution
Ulva 1st Ulva
Ulva Ist STS
Ulva 1st EDTA

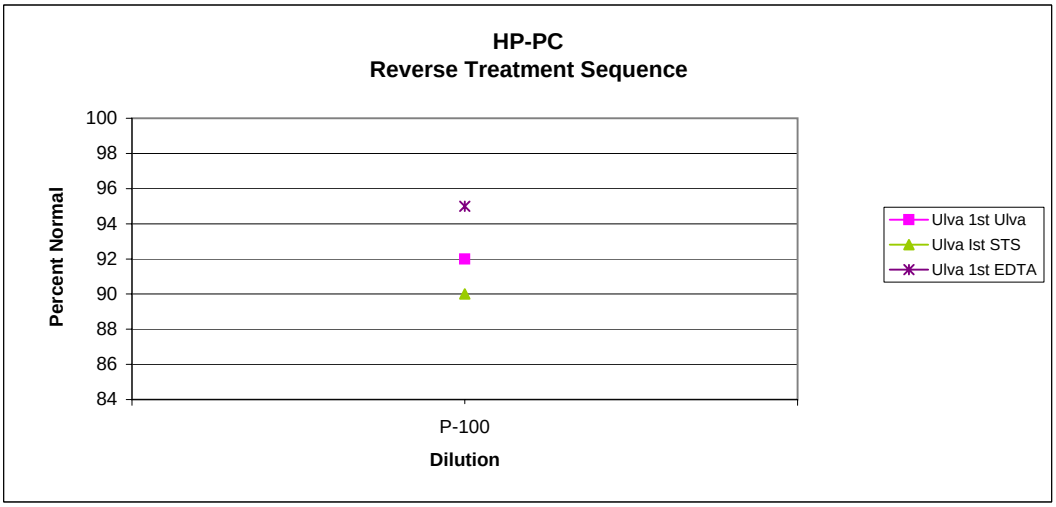

HP-9
Normal Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-1
P-10
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva
High pH


HP-9
Reverse Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-1
P-10
P-50
P-100
Dilution
Ulva 1st Ulva
Ulva Ist STS
Ulva 1st EDTA


HP-REF
Normal Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-1
P-10
P-50
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva
High pH


HP-REF
Reverse Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-1
P-10
P-50
P-100
Dilution
Ulva 1st Ulva
Ulva Ist STS
Ulva 1st EDTA


HP-PC
Normal Treatment Sequence
Percent Normal
100
90
80
70
60
50
40
30
20
10
0
P-100
Dilution
Untreated
STS
EDTA
Filtered
Oasis
Ulva
High pH


HP-PC
Reverse Treatment Sequence
Percent Normal
100
98
96
94
92
90
88
86
84
P-100
Dilution
Ulva 1st Ulva
Ulva Ist STS
Ulva 1st EDTA

Appendix B-4. Statistical summary of *Menidia menidia* LC_{20} and LC_{50} toxicity values for Hunter's Point TIE samples[1].

A. LC_{20} values.

Station ID	parameter	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH
HP-1	LC_{20} CL	>100	>100	>100	>100	>100	>100	>100
HP-2	LC_{20} CL	>100	>100	>100	>100	88.6 X	>100	>100
HP-3	LC_{20} CL	X	X	X	X	X	>100	X
HP-4	LC_{20} CL	60.0 (88.2-140.0)	>100	>100	>100	>100	>100	53.8 (106.7-158.5)
HP-5	LC_{20} CL	60.0 (60.0-71.4)	60.0 (71.4-73.3)	60.0 (60.0-75.0)	>100	60.0 (60.0-68.1)	>100	92.3 X
HP-6	LC_{20} CL	>100	>100	>100	>100	>100	>100	>100
HP-7	LC_{20} CL	>50 X	X	X	X	X	>100	73.1 X
HP-8	LC_{20} CL	X	X	X	X	X	>100	X
HP-9	LC_{20} CL	X	X	60.0 (60.0-83.1)	>100	60.0 (72.0-116.9)	>100	53.8 (106.7-158.5)
HP-10	LC_{20} CL	X	X	>100	X	X	>100	X
REF	LC_{20} CL	>100	>100	>100	>100	>100	>100	>100
Spike	LC_{20} CL	60.0 (60.0-71.4)	60.0 (72.0-162.9)	>100	>100	>100	>100	>100

B. LC_{50} values

Station ID	parameter	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH
HP-1	LC_{50} CL	>100	>100	>100	>100	>100	>100	>100
HP-2	LC_{50} CL	>100	>100	>100	>100	>100	>100	>100
HP-3	LC_{50} CL	X	X	X	X	X	>100	X
HP-4	LC_{50} CL	75.0 X	>100	>100	>100	>100	>100	71.2 X
HP-5	LC_{50} CL	75.0 (75.0-103.6)	75.0 (103.6-108.3)	75.0 (75.0-112.5)	>100	75.0 (75.0-95.3)	>100	>100
HP-6	LC_{50} CL	>100	>100	>100	>100	>100	>100	>100
HP-7	LC_{50} CL	>50 X	X	X	X	X	>100	>100
HP-8	LC_{50} CL	X	X	X	X	X	>100	X
HP-9	LC_{50} CL	X	X	75.0 X	>100	75.0 X	>100	71.2
HP-10	LC_{50} CL	X	X	>100	X	X	>100	X
REF	LC_{50} CL	>100	>100	>100	>100	>100	>100	>100
Spike	LC_{50} CL	75.0 (75.0-103.6)	75.0 X	>100	>100	>100	>100	>100

Note:
1 - Values calculated by linear interpolation, with bootstrapped 95% Confidence Limit (CL).
2 - SPE = Single Phase Extraction.
X: Not enough data available; Toxcalc unable to calculate value.
(Norber-King,1988) using the ToxCalc version 5.0.23 (Tidepool Software).
Concentrations for spiked sample were 200 ug/L fluoranthene (nominal) and 315 ug/L copper (measured);
140 mg/L ammonia was added after the Oasis step.

Appendix B-5. Statistical summary of *Strongylocentrotus purpuratus* LC_{20} and LC_{50} toxicity values for Hunter's Point TIE samples

A. LC_{20} values.

Station ID	parameter	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva
HP-1	LC_{20}	<10	<10	14.3	12.1	<10	<10
	CL			(11.6-17.2)	(7.5-17.5)		
HP-2	LC_{20}	<10	<10	11.6	11.0	<10	<10
	CL			(6.9-14.6)	(7.4-14.7)		
HP-3	LC_{20}	<10	<10	<10	<10	<10	10.0
	CL						(5.8-23.9)
HP-4	LC_{20}	<10	10.6	10.6	11.3	<10	34.1
	CL		(7.3-13.3)	(9.0-12.7)	(7.9-14.2)		(0.0-79.6)
HP-5	LC_{20}	<10	11.2	<10	11.5	<10	15.8
	CL		(9.7-12.7)		(9.1-14.0)		(4.2-34.8)
HP-6	LC_{20}	<10	<10	<10	28.8	<10	<10
	CL				(22.0-36.3)		
HP-7	LC_{20}	<10	<10	<10	X	<10	<10
	CL						
HP-8	LC_{20}	<10	<10	<10	<10	<10	<10
	CL						
HP-9	LC_{20}	<10	<10	<10	<10	<10	<10
	CL						
HP-10	LC_{20}	<10	<10	<10	<10	<10	<10
	CL						
REF	LC_{20}	<10	<10	<10	19.9	<10	<10
	CL				(10.9-30.6)		
Spike	LC_{20}	<10	<10	14.0	<10	<10	15.0
	CL			(0.0-23.6)			(4.4-73.3)

B. LC_{50} values

Station ID	parameter	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva
HP-1	LC_{50}	<10	15.0	23.5	22.1	12.6	>100
	CL		(3.5-20.3)	(19.5-30.1)	(19.4-25.4)	(6.2-19.1)	
HP-2	LC_{50}	<10	<10	22.2	19.0	10.4	>100
	CL			(19.8-24.7)	(16.9-21.3)	(8.8-12.4)	
HP-3	LC_{50}	<10	<10	<10	<10	<10	>100
	CL						
HP-4	LC_{50}	<10	17.5	17.9	17.2	13.9	86.6
	CL		(15.0-20.4)	(16.6-19.4)	(15.3-19.0)	(7.1-18.2)	(19.6-95.7)
HP-5	LC_{50}	10.6	16.4	<10	16.6	<10	59.3
	CL	(7.9-14.1)	(15.4-17.3)		(15.0-18.1)		X
HP-6	LC_{50}	<10	43.1	44.4	42.2	32.6	81.7
	CL		(36.3-49.9)	(36.2-53.1)	(36.7-50.7)	(16.6-43.0)	X
HP-7	LC_{50}	<10	10.2	11.2	X	10.9	24.8
	CL		(7.7-14.1)	(9.1-13.0)		(9.2-12.8)	X
HP-8	LC_{50}	<10	<10	<10	<10	<10	84.4
	CL						X
HP-9	LC_{50}	<10	13.6	11.2	13.3	11.8	70.3
	CL		(12.2-15.2)	(8.6-13.6)	(10.1-16.3)	(10.0-13.7)	X
HP-10	LC_{50}	<10	<10	<10	<10	<10	<10
	CL						
REF	LC_{50}	<10	17.3	25.8	34.2	10.0	>100
	CL		(7.8-25.4)	(14.6-28.2)	(30.9-37.6)	(8.5-19.7)	
Spike	LC_{50}	<10	<10	31.1	<10	<10	85.3
	CL			(27.4-34.1)			X

Note:
1 - Values calculated by linear interpolation, with bootstrapped 95% Confidence Limit (CL).
2 - SPE = Single Phase Extraction.
X: Not enough data available; Toxcalc unable to calculate value.
(Norber-King,1988) using the ToxCalc version 5.0.23 (Tidepool Software).
Concentrations for spiked sample were 200 ug/L fluoranthene (nominal) and 315 ug/L copper (measured); 140 mg/L ammonia was added after the Oasis step.

Appendix B-6. Statistical summary of *Dendraster excentricus* LC-20 and LC-50 LC_{20} and LC_{50} toxicity values for Hunter's Point TIE samples[1].

A. LC_{20} values.

Station ID	parameter	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH	Ulva 1st	Ulva 1st, STS 2nd	Ulva 1st, EDTA
HP-1	LC_{20}										
	CL										
HP-2	LC_{20}										
	CL										
HP-3	LC_{20}										
	CL										
HP-4	LC_{20}	17.9	17.8	18.1	18.1	15.0	>100	16.7	69.8	84.8	96.2
	CL	(16.1-18.4)	(16.7-18.3)	(15.8-18.3)	(16.8-18.5)	(8.1-20.9)		(15.4-18.0)	(63.2-76.7)	(69.9-91.4)	X
HP-5	LC_{20}	<10	<10	<10	<10	<10	53.7	<10	17.8	19.4	18.3
	CL						(47.4-58.4)		(15.9-18.5)	(18.4-20.8)	(15.8-19.3)
HP-6	LC_{20}										
	CL										
HP-7	LC_{20}										
	CL										
HP-8	LC_{20}										
	CL										
HP-9	LC_{20}	<10	<10	<10	<10	<10	56.5	13.6	22.1	58.9	60.1
	CL						(52.8-59.8)	(10.1-15.9)	(10.9-37.4)	(57.0-60.6)	(57.0-61.4)
HP-10	LC_{20}										
	CL										
REF	LC_{20}	20.9	22.2	51.1	41.2	32.3	76.9	28.9	72.4	91.8	>100
	CL	(15.0-23.6)	(17.6-25.7)	(33.0-58.6)	(29.5-64.0)	(19.2-59.5)	(69.7-88.3)	(14.4-50.5)	(58.1-83.9)	X	
Spike	LC_{20}										
	CL										

B. LC_{50} values

Station ID	parameter	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH	Ulva 1st	Ulva 1st, STS 2nd	Ulva 1st, EDTA
HP-1	LC_{50}										
	CL										
HP-2	LC_{50}										
	CL										
HP-3	LC_{50}										
	CL										
HP-4	LC_{50}	30.2	29.9	30.2	30.2	28.1	>100	29.2	>100	>100	>100
	CL	(29.1-30.6)	(29.2-30.2)	(28.6-30.9)	(29.3-31.3)	(23.8-31.8)		(28.4-30.0)			
HP-5	LC_{50}	<10	<10	18.4	22.0	<10	71.0	<10	30.0	33.6	31.1
	CL			(11.4-24.2)	(19.6-24.1)		(67.1-74.0)		(28.7-30.7)	(31.2-36.9)	(28.7-33.1)
HP-6	LC_{50}										
	CL										
HP-7	LC_{50}										
	CL										
HP-8	LC_{50}										
	CL										
HP-9	LC_{50}	<10	<10	<10	16.1	<10	72.8	27.3	55.0	74.9	76.2
	CL				(11.8-19.8)		(70.5-74.9)	(25.0-28.7)	(30.7-71.7)	(73.7-76.0)	(74.1-77.5)
HP-10	LC_{50}										
	CL										
REF	LC_{50}	38.9	40.8	69.5	66.5	61.2	>100	62.2	>100	>100	>100
	CL	(33.0-43.5)	(30.7-49.5)	(64.0-74.1)	(60.8-74.1)	(41.7-75.3)		(41.7-72.0)			
Spike	LC_{50}										
	CL										

Note:
1 - Values calculated by linear interpolation, with bootstrapped 95% Confidence Limit (CL).
2 - SPE = Single Phase Extraction.
X: Not enough data available; Toxcalc unable to calculate value.
(Norber-King,1988) using the ToxCalc version 5.0.23 (Tidepool Software).
Concentrations for spiked sample were 200 ug/L fluoranthene (nominal) and 315 ug/L copper (measured);
140 mg/L ammonia was added after the Oasis step.

Appendix B-7. Interpretive summary of *Menidia menidia* LC_{20} and LC_{50} toxicity values for Hunter's Point TIE samples.

A. LC_{20} values.

Station ID	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH
HP-1	*	*	*	*	*	*	*
HP-2	*	*	*	*	*	*	*
HP-3						*	
HP-4	+	v *	*	*	*	*	^ +
HP-5	+	+	+	v *	^ +	v *	*
HP-6	*	*	*	*	*	*	*
HP-7	*					*	^ +
HP-8						*	
HP-9			+	v *	^ +	v *	^ +
HP-10			*			*	
REF	*	*	*	*	*	*	*
Spike	+	+	v *	*	*	*	*

B. LC-50 values

Station ID	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH
HP-1	*	*	*	*	*	*	*
HP-2	*	*	*	*	*	*	*
HP-3						*	
HP-4	+	v *	*	*	*	*	^ +
HP-5	+	+	+	v *	^ +	v *	*
HP-6	*	*	*	*	*	*	*
HP-7	*					*	*
HP-8						*	
HP-9			+	v *	^ +	v *	^ +
HP-10			*			*	
REF	*	*	*	*	*	*	*
Spike	+	+	v *	*	*	*	*

Toxicity Codes:
If LC20>80 then "*" (not toxic); if 40 < LC20 < 80 then "+" (slightly toxic);
if 10 < LC20 < 40 then "++" (moderately toxic); if LC20 < 10 then "+++" (highly toxic).
Change in Toxicity:
If toxicity (no. of "+"s) reduces or increases by one category, then "v" or "^", respectively.
If toxicity (no. of "+"s) reduces or increases by > one category, then "vv" or "^^", respectively.
2 - SPE = Solid Phase Extraction.

Appendix B-8. Interpretive summary of *Strongylocentrotus purpuratus* LC_{20} and LC_{50} toxicity values for Hunter's Point TIE samples.

A. LC_{20} values.

Station ID	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva
HP-1	+++	+++	v ++	++	^ +++	+++
HP-2	+++	+++	v ++	++	^ +++	+++
HP-3	+++	+++	+++	+++	+++	v ++
HP-4	+++	v ++	++	++	^ +++	v ++
HP-5	+++	v ++	^ +++	v ++	^ +++	v ++
HP-6	+++	+++	+++	v ++	^ +++	+++
HP-7	+++	+++	+++		+++	+++
HP-8	+++	+++	+++	+++	+++	+++
HP-9	+++	+++	+++	+++	+++	+++
HP-10	+++	+++	+++	+++	+++	+++
REF	+++	+++	+++	v ++	^ +++	+++
Spike	+++	+++	v ++	^ +++	+++	v ++

B. LC_{50} values

Station ID	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva
HP-1	+++	v ++	++	++	++	vv *
HP-2	+++	+++	v ++	++	++	vv *
HP-3	+++	+++	+++	+++	+++	vv *
HP-4	+++	v ++	++	++	++	vv *
HP-5	++	++	^ +++	v ++	^ +++	vv +
HP-6	+++	vv +	+	+	^ ++	vv *
HP-7	+++	v ++	++		++	++
HP-8	+++	+++	+++	+++	+++	vv *
HP-9	+++	v ++	++	++	++	v +
HP-10	+++	+++	+++	+++	+++	+++
REF	+++	v ++	++	++	++	vv *
Spike	+++	+++	v ++	^ +++	+++	vv *

Toxicity Codes:

If LC20>80 then "*" (not toxic); if 40 < LC20 < 80 then "+" (slightly toxic);

if 10 < LC20 < 40 then "++" (moderately toxic); if LC20 < 10 then "+++" (highly toxic).

Change in Toxicity:

If toxicity (no. of "+"s) reduces or increases by one category, then "v" or "^", respectively.

If toxicity (no. of "+"s) reduces or increases by > one category, then "vv" or "^^", respectively.

2 - SPE = Solid Phase Extraction.

Appendix B-9. Interpretive summary of *Dendraster excentricus* LC_{20} and LC_{50} toxicity values for Hunter's Point TIE samples.

A. LC_{20} values.

Station ID	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH	Ulva 1st	Ulva 1st, STS 2nd	Ulva 1st, EDTA
HP-1										
HP-2										
HP-3										
HP-4	++	++	++	++	++	vv *	^ ++	v +	v *	*
HP-5	+++	+++	+++	+++	+++	vv +	^^ +++	v ++	++	++
HP-6										
HP-7										
HP-8										
HP-9	+++	+++	+++	+++	+++	vv +	^ ++	++	v +	+
HP-10										
REF	++	++	v +	+	^ ++	v +	^ ++	v +	v *	*
Spike										

B. LC_{50} values

Station ID	Untreated	STS	EDTA	Filtered	Oasis(2)	Ulva	High pH	Ulva 1st	Ulva 1st, STS 2nd	Ulva 1st, EDTA
HP-1										
HP-2										
HP-3										
HP-4	++	++	++	++	++	vv *	*	*	*	*
HP-5	+++	+++	v ++	++	^ +++	vv +	^^ +++	v ++	++	++
HP-6										
HP-7										
HP-8										
HP-9	+++	+++	+++	v ++	^ +++	vv +	^ ++	v +	+	+
HP-10										
REF	++	v +	+	+	+	v *	^ +	v *	*	*
Spike										

Toxicity Codes:
If LC20>80 then "*" (not toxic); if 40 < LC20 < 80 then "+" (slightly toxic);
if 10 < LC20 < 40 then "++" (moderately toxic); if LC20 < 10 then "+++" (highly toxic).
Change in Toxicity:
If toxicity (no. of "+"s) reduces or increases by one category, then "v" or "^", respectively.
If toxicity (no. of "+"s) reduces or increases by > one category, then "vv" or "^^", respectively.
2 - SPE = Solid Phase Extraction.

Appendix B-10. Dissolved oxygen in TIE samples below critical concentrations measured during TIE toxicity tests conducted for the Hunter's Point TIE investigation[1].

			Dissolved Oxygen (mg/L) in TIE Treatment						
Test species	SAIC TIE Sample ID	Dilution	Untreated	Filtered	Oasis	STS	EDTA	Ulva	High Ph
M. menidia	HP-2	50			0.9				
		100			1.6				
	HP-3	25					1.0		
		50	0.9						1.0
		100		0.7	1.2				0.6
	HP-4	10							1.3
		25							1.0
		50							1.0
		100			2.0				0.9
	HP-5	100							2.8
	HP-6	100						2.9	
	HP-8	100				0.7	0.7		1.4
	HP-9	25							2.0
		50							2.7
		100		0.8					1.1
	HP-10	50		0.6	2.3		3.1		
		100						1.8	
	HP-REF	100			3.1				
S. purpuratus	HP-2	50			0.9				
	HP-3	50	0.9						
		100		0.7					0.6
	HP-4	100							0.9
	HP-8	100				0.7	0.7		
	HP-9	100		0.8					
	HP-10	50		0.6					

1 - Critical concentration of 3.5 mg/L used for *M. menidia* (U.S. EPA, 2000); 1.0 mg/L used for *S. purpuratus* and *D. excentricus* .

Appendix C.
Hunters Point TIE Demonstration Work Plan

WORK PLAN FOR:

CONDUCT OF NAVY SEDIMENT TOXICITY IDENTIFICATION EVALUATION DEMONSTRATION:

HUNTERS POINT SHIPYARD
Parcel F

SUBMITTED TO:

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING SERVICE CENTER
NCBC CODE 27162 BUILDING 41
1000 23RD Avenue
Port Hueneme, CA 93043-4410

SUBMITTED BY:

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
221 THIRD STREET
NEWPORT, RI 02840

IN RESPONSE TO:

NAVY BAA N47408-97-D-0410

14 February 2001

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1.0 INTRODUCTION

The Hunters Point Shipyard, Parcel F, was chosen as the second of two sites to be evaluated as part of the Sediment Toxicity Identification Evaluation (TIE) Demonstration project for the Naval Facilities Engineering Service Center. The Technical Proposal for the Demonstration Project was submitted and approved in March 2000. The other site selected for the demonstration is the Naval Surface Warfare Center at Indian Head, a freshwater site in Maryland. Hunters Point was chosen as a Demonstration site because it conforms with the principal site-selection criteria developed for the project designed to resolve ecological risk concerns:

1. An identified need exists for information that may clarify the source of apparent toxicity. One objective of the on-going Feasibility Study (FS) for the site is to determine the chemical characteristics that will guide remedial decisions to treat, depose or investigate reuse options for the contaminated sediments. Thus, results from the TIE should help to resolve regulatory uncertainties and site management decisions.
2. The site presents a unique case study in relation to environmental and contaminant characteristics at the other chosen site. Hunters Point is a saltwater site incorporating numerous habitat types and sources of Contaminants of Potential Concern (CoPCs). Thus, the TIE program should demonstrate applicability in diverse habitat conditions, and serve to address uncertainties with regard to the principal toxic agents that may be found across a wide variety of navy sites.

Existing data supported the need for a Validation Study antecedent to a Feasibility Study (FS) of remedial options (Battelle et al., 1999; Battelle et al., 2000). The Southwest Division (SWDIV) Naval Facilities Engineering Command (NAVFAC) is performing the Validation Study for offshore sediments (Parcel F) at the Hunters Point Shipyard (HPS) in San Francisco Bay to clearly identify areas that require consideration in the FS of remedial alternatives for Parcel F sediments. The Validation Study will focus on areas that have been characterized as the "Low-Volume Footprint", as identified in the Parcel F Feasibility Study Draft Report, Hunters Point Shipyard, San Francisco, California (Tetra Tech EMI and LFR, 1998). The CoPC list includes metals, PAHs, PCB-aroclors, PCB-congeners, pesticides and Total Petroleum Hydrocarbon (TPH). The proposed Phase 1 TIE study will provide data to evaluate degrees of risk associated with CoPCs at the site. It will also characterize the extent to which confounding factors (e.g., ammonia, sulfides) are potentially involved in observed toxicity.

Specific objectives for the Hunters Point TIE are to evaluate:

- The utility of the TIE findings in providing clarification/enhanced certainty with respect to causes of site-related risks;
- Potential cost/benefits resulting from performance of the TIE demonstration; and
- Regulatory acceptance of TIE methodology as a legitimate ERA tool.

A site description and history, as well as a review of the findings from previous studies has been provided in the Hunters Point Shipyard Parcel F Validation Study Work Plan (Battelle et al., 2000a). An advantage in the choice of Hunters Point as a site for the TIE demonstration is that field surveys and toxicity-testing activities will be supported through the Validation Study for the site. The NORTHDIV TIE demonstration to be conducted by SAIC reflects the shared interest of all parties involved to efficiently coordinate a plan that is mutually beneficial. SAIC, Navy and contract personnel involved in the Validation Study are committed to the collaborative effort.

Details regarding the field sampling plan for surface sediment collection as well as additional sampling and data collection associated with the Validation Study (Battelle et al., 2000a) have been reviewed in order to develop a TIE plan that is highly collaborative.

The Program Team involved in addressing remediation at the site includes the primary technical team (SAIC), the Navy Northern Division (NORTHDIV) oversight/liaison team, the Installation Restoration support team (SWDIV IR staff and contractors), and Regulatory Team (Hunters Point Base Closure Team). The Program Team is committed to a close collaboration with the TIE effort to assure successful and efficient study designs and sampling efforts.

2.0 SAMPLING DESIGN FOR THE HUNTERS POINT SHIPYARD SITE

2.1. STRATEGY FOR EVALUATING POTENTIAL TOXICITY OF CONTAMINATED SEDIMENTS

The objectives of the proposed Phase 1 TIE study are to provide data to identify sources and magnitude of toxicity associated with CoPCs at the site. It will also characterize the extent to which confounding factors (e.g., ammonia, sulfides) are potentially involved in the toxic response. The sampling design derived to meet these objectives is discussed in this section and; the technical approaches for field and laboratory analysis procedures are discussed in Section 3.

The choice of sediment sampling locations within Hunters Point Shipyard emphasizes sites with measured CoPCs that exceed NOAA ERM benchmark concentrations. Hazard Quotients (HQs) calculated as the ratio of Sediment Concentrations/ERM, indicate that cationic metals, tributyl tin (TBT) and PCBs apparently represent the greatest risks to aquatic receptors (Battelle et al., 2000b; Poucher and Tracey, 2000). For purposes of the TIE Demonstration, the stations were selected according to the following criteria:

- Bulk sediment concentrations exceed benchmarks for potential/probable effects;
- Mediating factors (e.g., TOC, AVS) that may affect chemical bioavailability;
- Confounding factors (e.g., NH_4) that directly contribute to toxicity;
- Contaminants other than cationic metal CoPCs (e.g., TBT, PCBs, PAHs) may

contribute to toxicity, based on benchmark Hazard Quotients (HQs);
- Spatial distribution that reflects unique contaminant sources and different environmental conditions or CoPC distributions that represent gradients in chemical availability.

The concentration of Acid Volatile Sulfides (AVS) relative to total metal and the amount of dissolved and particulate organic carbon may all mediate the availability of CoPCs. Ammonia and sulfides as well as uptake mechanisms and enzymatic processing within organisms may also influence toxicity. Though progress has been made in sediment toxicology, many of the drivers of toxicity remain unresolved. TIE testing serves to deduce which classes of contaminants and sediment quality characteristics govern sediment toxicity on a site-specific basis.

Simultaneously Extracted Metal (SEM) concentration. Research into the bioavailability and toxicity of metals has found that for some metals, sulfides (measured as Acid Volatile Sulfides, AVS) in sediments can act as an important binding compound that can prevent toxicity as long as the quantity of AVS is in excess of the total amount of metals (measured as SEM). Sulfides are a common constituent of organic-rich sediments that do not have prolonged exposure to oxygen in the water column (e.g., hypoxic).

Confounding factors affecting bioavailability and toxicity. In the historical and recent surveys conducted at Hunters Point, sediment constituents were measured to varying degrees, resulting in uncertainty with regard to the potential for toxicity of CoPCs versus confounding factors. A limited number of samples were analyzed for organic carbon, and ammonia. SEM/AVS and sulfide concentrations have not been measured. Still, the available data indicate that locations generally characterized by lower organic carbon and or alternatively, high ammonia, have the greatest potential for toxicity. In the present study, stations with varying TOC, SEM/AVS, ammonia and/or sulfides will provide data to address site-specific effects on potential COPC toxicity.

Information concerning ammonia toxicity to echinoderms in embryo-larval tests (U.S EPA, 1993; Greenstein, Alzadjali and Bay, 1995) indicates that this group is much more sensitive than other taxa (U.S. EPA, 1988). In tests with *Strongylocentrotus purpuratus* embryos, the LC50 in expressed as total ammonia ranged from 7.2 mg/L at pH 7.7 to 1.4 mg/L at pH 8.4 (Greenstein, Alzadjali and Bay, 1995). Available ammonia data corresponding to observed bulk sediment toxicity of the Hunters Point site sediments ranged from 12 to 100 mg/L in the sediment pore waters. This indicates that ammonia was a probable source of toxicity observed in tests with *S. purpuratus*, however ammonia-only tests should be conducted with this species using ambient water. This would provide results that could be used to derive site specific ammonia HQs.

Spatial distributions. Another important consideration in selecting stations for the TIE Demonstration at Hunters Point Shipyard is the relatively broad area of concern. The TIE stations selected are from four distinct areas within the study area: (1) Point Avisadero; (2) Eastern Wetlands; (3) Oil Reclamation Area; and (4) South Basin (see Appendix A).

Samples for the TIE were chosen to reflect the potential for multiple sources of contamination. Also, the vertical distribution of contaminants at Hunters Point is an important consideration. The depth profile of contaminants must be considered in terms of associated gradients in toxicity and the potential for aquatic organism exposures. The choice of stations for TIE evaluation of subsurface sediment was based on criteria that reflect an emphasis on depositional areas where core sampling is planned, with radioisotopic and/or hazardous waste characterizations. Availability of data from independent chemical characterizations of the stations (other than the FS study) was also considered in narrowing the selection to three subsurface stations (Battelle, 2001).

2.2. RATIONALE FOR SELECTION OF SPECIFIC STATIONS

Table 2-1 describes each of 12 proposed locations in terms of the characteristics that led to its selection, with particular emphasis on factors that may influence toxicity associated with elevated heavy metals. Three additional samples will be taken to determine the depth distribution of contaminants and associated toxicity. They will be collected from the 5-10 cm strata as secondary collections following surface sampling (0-5 cm) at the same station. The stations have been chosen not only to maximize opportunities to observe and characterize potential toxicity from COPC and confounding factors, but also to provide a representation of the varying contaminant signatures and sediment characteristics that occur across the Low-Volume Footprint areas.

The stations for the TIE were selected from the following areas:
Point Avisadero (PA); Stations 38-41, plus 5-10 cm samples at Station 40 and 41
Eastern Wetlands (EW); Station 33
Oil Reclamation Area (OR); Station 24
South Basin (SB); Stations 18-23, plus 5-10 cm samples at Station 20

In the PA area, four stations were chosen to represent the sites where Cu, Zn and Pb all exceeded ERL values. Pore water Cu was also measured at levels that exceeded acute WQC Stations PA 40 and PA 41 were selected for TIE testing on pore waters from subsurface sediments because of the known elevations in CoPCs, as well as expected differences in sediment characteristics with depth (Battelle, 2001)

One station was selected in both the EW and OR areas, mostly in order to represent the potential differences in toxic signatures at the two sites. The EW station represents a single hot spot in the area with four target CoPCs exceeding ERM levels. The OR station has been characterized with Cu, Zn and PB above ERL values.

In the South Basin Area six stations on the eastern bank were selected for the TIE to represent toxic sediment with a mixture of contaminants that exceed ERL values but with consistent ERM exceedences for Zn. The third subsurface sample will be taken from SB 20, because of its proximity to a landfill (Battelle, 2001). The locations of each station are presented in Appendix B.

3.0 TECHNICAL APPROACH

The following sections describe the rationale and methods for TIE testing, chemical analysis of pore waters and data interpretation. Field sampling will be conducted in conjunction with the SWDIV-NAVFAC Hunters Point 'Low Volume Footprint' Validation Study. Sediment samples, prepared as splits of the collected and homogenized bulk sediments, will be provided to SAIC by SWDIV-NAVFAC's contractor (Battelle) for the TIE study. Toxicity characterization, including the bulk sediment tests that normally precede sediment TIE testing, will also be conducted by SWDIV's contractor (see below). As an integral part of the Validation Study, the sediments will also be analyzed for priority contaminants, including all CoPCs. The resulting data, as well as other measurements that are critical in the evaluation of sediment characteristics associated with toxicity, including total organic carbon (TOC), grain size and percent moisture, will be provided to SAIC (Battelle et al., 2000a; Battelle et al. 2001). SAIC will be responsible for the laboratory analyses of porewater metals, as well as TOC, DOC, ammonia, sulfides and standard water quality parameters measured during biological testing (i.e. salinity, pH, D.O.). If SEM and AVS are not measured in sediment samples as part of the Validation Study SAIC will be responsible for these analyses for samples from TIE stations. The technical approach proposed for toxicity and chemical characterizations associated with the TIEs to be conducted on sediment pore waters are described below.

3.1. FIELD SAMPLING

3.1.1. TOXICITY CHARACTERIZATION

TIE sample selection/porewater extraction. Upon completion of toxicity tests conducted for the Validation Study, ten sediment samples will be selected for the porewater TIE. The following information will be reviewed prior to selection of samples for TIE analyses:

- Results from preliminary pore water analyses (salinity, pH, ammonia and sulfides; see below).
- Toxicity test results, including the following, as available;
    - Bulk sediment survival of *Eohaustorius estuaries*
    - SWI echinoderm larval development
    - SPP echinoderm larval development

These data will be used to assure that the pore water TIE is conducted on toxic samples; as non-toxic or marginally toxic samples are unlikely to produce meaningful TIE results. In conjunction with the demonstration of toxicity, the selection will also be based on original study objectives, to characterize the factors that drive observed toxicity. Representation of spatial variability (including vertical profiling) is also a priority.

Pore water screening tests will be conducted on samples from the ten stations chosen for the TIE. For the screening test, 60 ml of pore water will be extracted from homogenized sediments using the syringe extraction method (Winger and Lassier, 1991). This method

will serve as an efficient means to collect the small volume required for the screening test, with minimal disruption of the sediments. The echinoderm larval development test will be performed on 100% pore water, with three replicates per sample. Results from this test will be used to determine the number of dilutions to be used in the TIE for each sample. If the screening test results in ≥ 50% reduction in normal development relative to the control response, a four dilution series (10%, 25%, 50% and 100%) TIE will be conducted. If less than a 50% effect is observed, only the 50% and 100% pore water samples will be tested in the TIE manipulation series. The TIE series will only be performed on samples that are statistically difference from the controls (one tailed T test) in the screening test.

Approximately two liters of pore waters for the TIE will be extracted by centrifugation at 5200 revolutions per minute (RPM). Centrifugation is an efficient method that allows the collection of sufficient pore water in a shorter time frame than would be required using the syringe method (which can require up to three days, depending on the number of syringes applied to each sediment). Water for control exposures and dilution water will be clean saltwater, filtered to 10*u*, in all TIE tests. Also, reference treatments for TIE tests will consist of pore water extracted from the Paradise Cove reference sediment.

TIE procedures. In a TIE investigation, the physical/chemical properties of sediment pore water samples are manipulated in order to alter or render biologically unavailable generic classes of chemicals (U.S. EPA 1991). Because sediments posing potential risks are usually toxic to aquatic organisms, fractions exhibiting toxicity reveal the nature of the toxicant(s). Depending upon the responses, the toxicant(s) can be tentatively categorized as having chemical characteristics of non-polar organics, cationic metals or confounding factors such as ammonia (U.S. EPA 1996).

Procedures for conducting specific TIE steps developed by EPA (1996) describing specific methodologies and QA/QC procedures form the basis for the proposed technical approach. SAIC has improved on the EPA approach by applying sequential testing of fractions and documentation of cumulative removal up to and including the production of completely non-toxic samples (Figure 3.1). Using the sequential approach, absence of residual toxicity provides a clearer demonstration that all the relevant chemical exposures in a sample can be adequately accounted for. SAIC's approach has been successfully demonstrated at the Naval Submarine Base-New London, CT at an IR site (Goss Cove) for Northern Division (Navy RPM News 1999; SAIC 1999). Prior remedial investigation and risk assessment studies for the site have suggested actionable risk although considerable uncertainty existed as to the contaminants responsible for risk. The application of the improved TIE process revealed that ammonia (a ubiquitous non-CoPC sediment constituent) and not the conventional sediment contaminants (e.g., PAHs, metals) was responsible for the risk.

The proposed Phase I TIE characterization will consist of the following recommended characterization steps or tiers: (1) Baseline Toxicity Test; (1a) Filtration; (2) C_{18} column extraction; (3) sodium thiosulfate; (4) Ethylenediamine Tetraacetic Acid (EDTA); and (5)

zeolite. In addition, low/high pH adjustments of the EDTA treated sample are also performed in parallel with the zeolite treatment. Guidelines for TIE data interpretation are presented in U.S. EPA (1991) and are summarized below:

1. **Baseline Toxicity Test**: Toxicity in exposures to whole pore water indicates the presence of bioavailable chemicals or other confounding factors (e.g., ammonia). Good survival in these exposures indicates that toxicity observed in the solid phase test is due to a factor(s) that is solely associated with the particle phase of the sediments. Toxicity due to extremes of sediment grain size (e.g., extremely coarse or fine) is an example of this type of effect.

1a. **Filtration.** Prior to C_{18} extraction, the pore water will be filtered with 0.45µm filter paper to remove particulates that would otherwise consume sites on the extraction column. In addition, toxicity tests conducted on the pre- and post-filtered fraction will allow for expression of any potential toxicity associated with large colloids or particulates trapped on the filter. The filters will be retained in order that chemical analysis may be conducted to quantify potential CoPC losses in this step.

2. **C_{18} column extraction**: Pore water samples will be subjected to C_{18} extraction to remove organic compounds and metals that are relatively non-polar (U.S. EPA 1991). A non-toxic response in these exposures will indicate the potential role of organic compounds as the sole contributor to toxicity of pore waters. A fully toxic response will indicate that organic compounds are not responsible for observed pore water toxicity. A partial reduction in toxicity would define a joint toxic action by organic compounds and other factors.

3. **Sodium thiosulfate**: Sodium thiosulfate ($Na_2S_2O_3$) will be used to reduce oxidants such as chlorine, ozone, chlorine dioxide, mono and dichloramines, bromine, iodine, manganous ions, and some electrophilic organic chemicals and to remove cationic metals including Cd^{2+}, Cu^{2+}, Ag^{1+}, and Hg^{2+} in the pore water samples (U.S. EPA 1991). Reduced toxicity or a non-toxic response will indicate oxidants or cationic metals as contributors to toxicity.

4. **EDTA chelation**: Samples will be subjected to EDTA chelation to remove divalent cationic metals (i.e., Al^{2+}, Ba^{2+}, Fe^{2+}, Mn^{2+}, Sr^{2+}, Cu^{2+}, Ni^{2+}, Pb^{2+}, Cd^{2+}, Co^{2+}, and Zn^{2+}) (Schubauer-Berigan et al. 1993a; U.S. EPA 1991). A non-toxic response or a partial reduction in toxicity indicates metals as a toxic component of the pore water. A fully or partially toxic response indicates that something other than divalent cationic metallic compounds is a contributor to sediment toxicity.

5. **Zeolite treatment**: Samples will be manipulated using a zeolite cation exchange resin to remove ammonia (Ankley et al. 1990; Besser et al. 1998; Jop et al. 1991; Van Sprang and Janssen 1997). A non-toxic sample will indicate the presence of ammonia as contributing to pore water toxicity in the precursor sample. A partial toxic response is not expected since organics, metals, oxidants, hydrogen sulfide, pH-

dependent toxicants, and ammonia will have been sequentially removed from the samples.

Graduated pH: In this procedure, sample pH is manipulated to determine if pH dependent toxicants such as speciated metals, ammonia, hydrogen sulfide, cyanide and some ionizable organic compounds (e.g., pentachlorphenol) are responsible for observed toxicity (Schubauer-Berigan et al. 1993a; Schubauer-Berigan et al. 1993b; U.S. EPA, 1993). For instance, if sample toxicity increases with increasing pH, toxicants such as ammonia are suspected. Conversely, if sample toxicity increases with decreasing sample pH, toxicants such as hydrogen sulfide are suspected. Typical pH adjustments include 1.0 pH units above and below ambient pH (e.g., pH 7 and pH 9 for ambient pH 8).

The pore water will be manipulated according to the sequential extraction scheme shown in Figure 3-1. They will be tested with species that are appropriate for the site and are also amenable to TIE testing protocols. In addition to the extracted water from ten site and one reference sediment, water from a performance control (i.e., clean seawater) will be evaluated. Also, a clean seawater sample spiked to produce toxic concentrations of a metal CoPC (e.g. copper), an organic contaminant (e.g. a PCB-aroclor mixture) and ammonia will be included as a positive control. The seawater control will be run in parallel to each manipulation. Thus, 104 toxicity tests (13 samples x 8 treatments) will be performed with two species.

Biological Tests tc "2.4.3. Toxicity Characterization " \l 3 . To assure relevance of the SAIC TIE Program in characterizing the sources of toxicity to aquatic receptors of concern in the Hunter's Point Validation Study, the echinoderm larval development test will be one of the two tests performed. SAIC's analysis of the test results will involve determining the percent normal development of test organisms relative to stocking density, and subsequently, derivation of concentration of pore water that produces a 50% reduction in survival (LC-50) in the untreated and manipulated samples. Other endpoints (e.g., LC-20) may also be derived using the ToxCalc statistical software package (Tidepool Scientific Software, 2000). The source of parent stock for the echinoderm test will be the same as that used in the other planned Validation Study tests.

A second species will also be tested in the pore water TIE series, as differential sensitivity to the classes of contaminants under study can be used to deduce the causes of observed toxicity. For the Hunters Point study, the inland silverside (*Menidia berylinna* embryo-hatch test will be employed because it is allows representation of a vertebrate receptor to compliment the echinoderm, and because susceptibility to many contaminants is particularly well-characterized for this species. Test procedures will generally follow the reduced-volume methodology developed by the EPA for TIEs (EPA/600/R-96-054, 1996).

Test conditions for the echinoderm larval development test and *M. beryllina* are presented in Table 3-1.

3.2. CHEMICAL ANALYSES

Laboratory analysis of metal and organic contaminants in bulk sediments will conform with NOAA's Recommended Target analytes (NOAA 1998), and will be conducted by Battelle for the FS Study. Sediment chemistry analyses will be performed using the methods developed by NOAA for use in the NOAA Status and Trends (NS&T) program because the methods are especially sensitive and appropriate for measurement of trace metal and organic contaminants in marine and estuarine sediment (NOAA, 1998). Battelle's sediment evaluations will also include measurements TOC, moisture content and grain size distributions for each sample. Battelle will also supply other results from sediment and initial pore water analyses, including salinity, pH, ammonia and sulfides, and QA/QC erratum for all analyses, upon availability (Battelle et al., 2000). If SEM and AVS are not measured for the VS, then SAIC will assure that these measurements are made on the TIE sediments. The analytical procedure for SEM/AVS involves an acid digestion and a cold-acid purge and trap technique. AVS is analyzed by titration. The SEM concentration reported is the sum of cadmium, copper, lead, nickel and zinc.

The eleven sediment pore waters plus the spiked seawater sample used in the TIE study will be split for toxicity analysis and laboratory analyses of metals. Like the sediment analysis, pore waters will be measured in accordance with NS&T protocols (NOAA, 1998). Specifically, a radio-frequency inductively coupled plasma (ICP) method will be applied following mineral acid digestion. In order to assess the bioavailability of potential toxicants, DOC (EPA Method 415.1)and TOC (EPA Method 415.1) in the pore waters will also be measured. These measurements, in addition to results from ammonia and sulfide analyses will be provide by SAIC to Battelle upon availability. Table 3-2 summarizes the analytical methods and Minimum Detection Limits (MDLs) that will be applied to the pore water samples.

3.3. DATA ANALYSIS AND REPORTING

For TIE results, survival of each species in each dilution series will be used to generate LC-20 and LC-50 values. These values will be calculated by linear interpolation, and confidence intervals were generated by the bootstrapping technique. ToxCalc software [version 4.0.8] from Tide Pool Scientific Software, 2000) will be used to generate test statistics. To perform hypothesis testing for statistical differences from controls (α = 0.05), results from each dilution will be evaluated by ANOVA followed by Dunnett's test. A test for normality of the distribution of the data (Shapiro-Wilkes test) will also be conducted because Dunnett's test results are most valid with normally distributed data. A report documenting data results and conclusions produced from the TIE investigation will be produced. From this report, SAIC will be prepared to present the results of the site investigation to the Program Team.

4.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

SAIC will be responsible for the overall technical and fiscal management of the TIE Demonstration project including the laboratory analyses activities described below. NFESC personnel will be responsible for the contract management, supportive technical oversight and coordination among federal and state regulatory agencies, if needed. NORTHDIV personnel will be responsible for additional technical oversight and project management dealing with on-site activities and coordination between SAIC, NFESC, and Navy site representatives.

Key Navy personnel for this project are:
Ruth Owens, NFESC Technical Point of Contact (POC)
Jason Speicher, NORTHDIV Technical Point of Contact (POC)
Dave Barclift, NORTHDIV Technical Point of Contact (POC)
Michael Pound, Deputy Chief Environmental Engineer for Restoration (SWDIV)

Key SWDIV contractor (Battelle) POC for coordination of this project is:
Jeff Ward, Senior Research Scientist

Key SAIC personnel supporting the project include:
Gregory Tracey, Program Manager
Sherry Poucher, Lead for Toxicological Analyses
Cornelia Mueller, Quality Assurance Officer

5.0 DELIVERABLE PRODUCTS AND SCHEDULE

A summary of Deliverable Products (DP) and schedule are summarized below. All deliverable products are considered accepted upon delivery. SAIC will prepare all reports and products in a SAIC-specified format. All scheduled delivery dates are contingent on the VS schedule, and therefore, the dates presented below should be considered as estimates.

5.1. LABORATORY ANALYSIS

SAIC will conduct laboratory analyses according to the site-specific work plan. Laboratory analyses as documented in monthly progress reports will be completed approximately 4 weeks after receipt of field sampling and toxicity test results

- Deliverable Product: TIE test results and data report:
  Estimated Due Date: 7/25/01
- Schedule required to meet Estimated Due Date:
  Sediment sampling: Completion by 5/25/01
  Toxicity reports: Delivery to SAIC by 6/27/01

5.2. SITE REPORT PREPARATION

SAIC will prepare a draft and final TIE site report (50-100 pp text). Electronic copies of the report will be sent to all Navy personnel and Navy Contractors involved with THE project, as designated by the SWDIV POC. Up to ten hard copies of the draft and final report, including all appendices, photographs, and graphics will also be distributed. One electronic copy of the final report will be submitted on CD-ROM. Tables will be provided in EXCEL.

- Deliverable Product: Draft Site 2 TIE Report.
  Estimated Due date: 8/27/01.
  Receive review comments: 4 weeks after submission of Draft.
- Deliverable Product: Final Site 2 TIE Report, incorporating comments on Draft.
  Estimated Due date: 10/29/014 (4 weeks after receipt of all comments on Draft).

6.0 TECHNICAL ASSUMPTIONS

6.1. ASSUMPTIONS REGARDING FIELD AND LABORATORY ACTIVITIES

- Field operations at Hunters Point Shipyard will be coordinated and conducted by Battelle for both the SWDIV Validation Study and the NORTHDIV TIE Demonstration project. Sediment samples will be delivered to SAIC following a schedule that complies with sediment holding times, allowing time for pore water extraction and completion of the TIE (i.e., no more than one month from the sample date).
- Battelle will supply data from all laboratory testing, including toxicity tests and chemical analyses, as they become available (i.e. within one week of completion)
- SAIC will subcontract all necessary chemical and toxicity analyses in accordance with the TIE work plan.
- All laboratory porewater metal analyses conducted for SAIC will be performed in accordance with NOAA NS&T (1998) protocols. Laboratory data reports will be included in the TIE report and contain detail sufficient for EPA Reduced Level III data validation.

6.2. ASSUMPTIONS REGARDING DELIVERABLE REPORTS

- Draft and Final Reports will be sent to 1) the facility environmental representative, 2) the Navy's IR RPM for the facility, 3) the NFESC POC, 4) the NORTHDIV POC, and 5) to regulators and trustees as designated by the SWDIV POC. Ten copies of the report are assumed for each deliverable.
- In addition to the hard copy distribution of the final report, a copy of the final report will be provided in PDF format to the Navy IR RPM and NFESC POC.

- The SAIC PM (and supporting personnel as deemed necessary by SAIC) will attend one technical meeting coupled with a Restoration Advisory Board (RAB) meeting to present the results of each investigation and SAIC's recommendations.

7.0 QUALITY ASSURANCE

The letter of transmittal for the report submission will include a certification that it has been subjected to SAIC's own review and coordination procedures to ensure: (a) completeness for each discipline commensurate with the level of effort required for that submission, (b) elimination of conflicts, errors, and omissions, and (c) the overall professional and technical accuracy of the submission.

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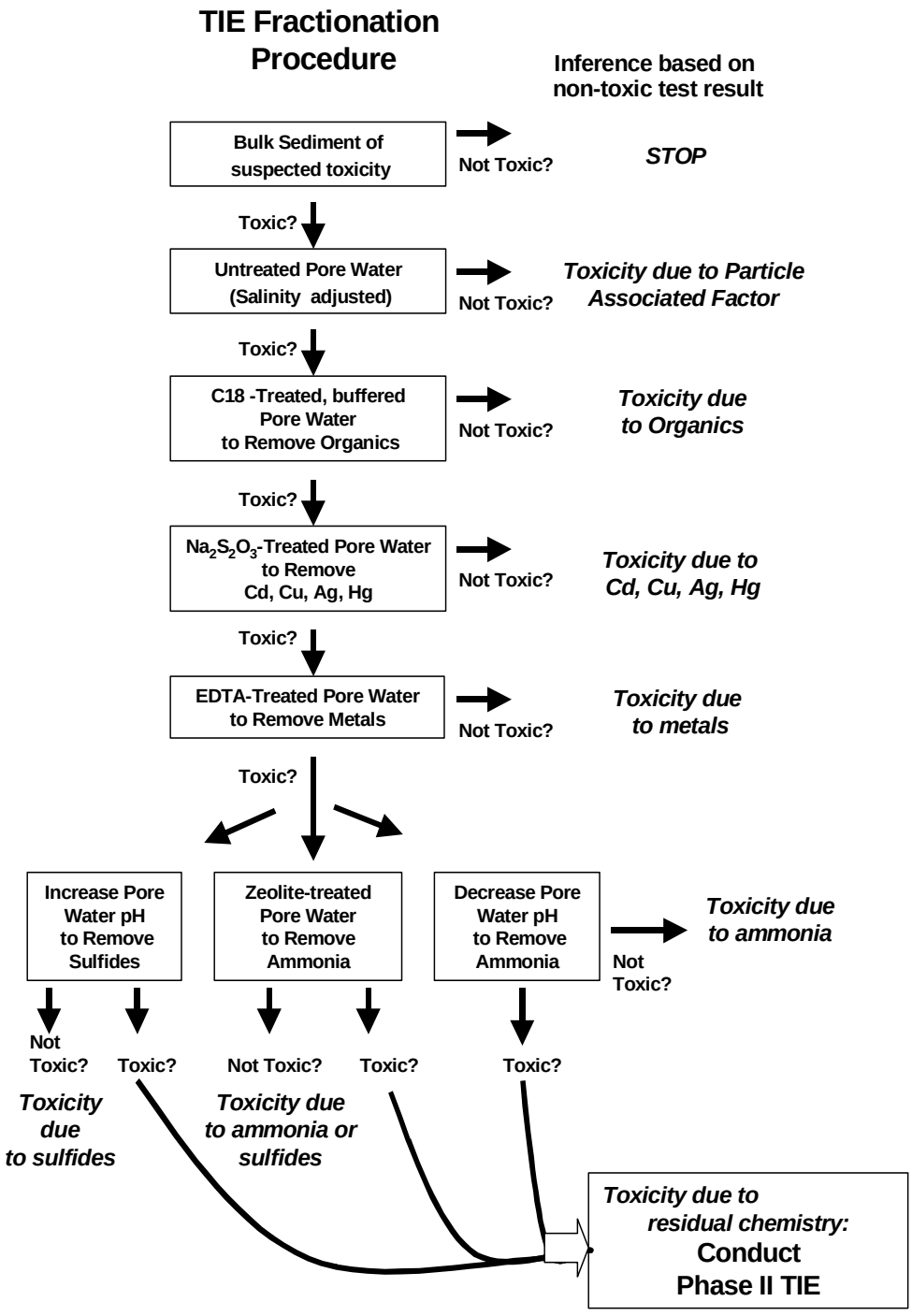

Figure 3-1. Toxicity Identification Evaluation porewater chemical fractionation procedure.

Table 2-1 Selection of Stations for the Hunters Point Shipyard TIE Demonstration.

Previous Toxicity Test Sites Listed By Area	Proposed Valid. Study Station	COCs relative to sediment benchmarks ✔ and porewater HQs ( )				NH4 (mg/L) o.w./ sed	TOC% /Fines	Toxicity Test Results Larval Development PW %LC50	Comments[a]
		Cu	Zn	Pb	PCB				
Area III	PA38 PA39 PA40 PA41	✔	✔	✔	--				PW toxic units >1 for Cu. Other metals not measured
TC 01		--				1.3/24		71.8	
TD01		✔ (1.7)	--	--	--	1.5/28	0.5/64	--	
TD03		✔ (1.5)				1.0/22		70.6	
Area VIII	EW33	✔ ✔	✔ ✔	✔ ✔	✔ ✔				Wetland site Low ammonia, small hot spot, LC50 =70 at one station near hot spot;other three had no toxicity
TV01		✔	✔	✔	--	1.0/12	0.11/17	70	
Area IX	OR24 (near-shore)	✔	✔	✔	✔ ✔				No tox. test sites represented in Verification Plan
TY04									
TX05 (not near-shore)		✔ ✔	--	--	NM		1.2/98 0.9/99.4	-- --	
Area X	SB (D) SB02								Large area broadly affected with all 4 CoCs; hot spots on eastern flank Zn>Cu
TX02		✔ ✔	✔ ✔	✔ ✔	✔ ✔	2/142	1.3/85	71.1	
TY02						3/50	1.3/96.9	72.9	
TY03						3/63	1.4/99.5	88.7	
TZ03	(6)					1/45	1.6/75.8	71.8	
S1S01						3/73	1.5/99.2	71.1	

✔ = > ERL ✔ ✔ > ERM; Porewater HQs = porewater concentration/WQC Acute Values
For proposed sites, comparisons to NOAA values were made using 0400RSCD Maps (Historical data and RSC Screening values; see Battelle et al., 2000b)
[a] General station characterizations providing either summary or ancillary information used in the station selection process.

Table 3-1. Summary of test conditions for acute water-only toxicity tests with the saltwater fish, *Menidia beryllina*[a] and the saltwaterwater echinoderm, *Strogylocentotus purpuratus*[b]

	M. beryllina	*S. purpuratus*
Test type	Static non-renewal	Static non-renewal
Test Duration	96 hr	72 hr
Number of Replicates per Treatment	3	3
Number of Organisms per Chamber	5	See note
Test Chambers	25 mL vial	25 mL vial
Test Temperature	15^{o}C	15 ^{o}C
Test concentrations	4 (10, 25, 50, 100%)	4 (10, 25, 50, 100%)
Salinity	10-32 ppt	30 ppt
Photoperiod	16:8	16:8
Age/Size of Test Organisms	1 day pre-hatch	
Volume of Overlying Water	20 mL	20 mL
Type of Water	clean seawaterwater	clean seawater
Bay Feeding/Chamber	none	none
Endpoint	time-to-hatch; survival	normal dev't
Physical measurements[1]	Dissolved oxygen, pH ammonia, temperature	Dissolved oxygen, pH ammonia, temperature
Acceptance Criteria	85% survival in control	65% normal dev't in control

[a] U.S. EPA, 1991a. Methods for aquatic toxicity identification evaluations: Phase I toxicity characterization procedures. EPA-600/3-88-034. Environmental Research Laboratory, Duluth, MN.

[b] American Society for Testing and Materials. 1998. Standard Guide for Conducting Static Acute Toxicity Tests Starting with Echinoid Embryos. ASTM E 1563-98. American Society for Testing and Materials, Philadelphia, PA.

1- measured for each treatment prior to addition of test organisms, and as required to monitor stability.

Initial stocking density estimates will be used to determine control development to pluteus stage.

Table 3-2. Analytes measured in pore waters for the Indian Head TIE demonstration program.

Analytes for Sediment Analyses	*Method*	*Description*	*Unit*	*MDL*	*Laboratory RL*
Cadmium	6020	ICP/MS	µg/L	0.19	2.0
Copper	6020	ICP/MS	µg/L	1.4	2.0
Lead	6020	ICP/MS	µg/L	0.22	2.0
Nickel	6020	ICP/MS	µg/L	1.1	2.0
Silver	6020	ICP/MS	µg/L	0.15	2.0
Zinc	6020	ICP/MS	µg/L	4.0	10.0
Arsenic	6020	ICP/MS	µg/L	0.24	2.0
Iron	6020	ICP/MS	µg/L	85	200
Aluminum	6020	ICP/MS	µg/L	17	20
TOC	SW9060	Combustion	mg/L	0.19	1.0
Sulfide	SW9034	Titration	mg/L	0.25	1.0

Appendix A

Hunters Point Areas included in the Validation Study of the 'Low-Volume Footprint'

(from the Hunters Point Validation Study Work Plan, (Draft Final; September, 2000)

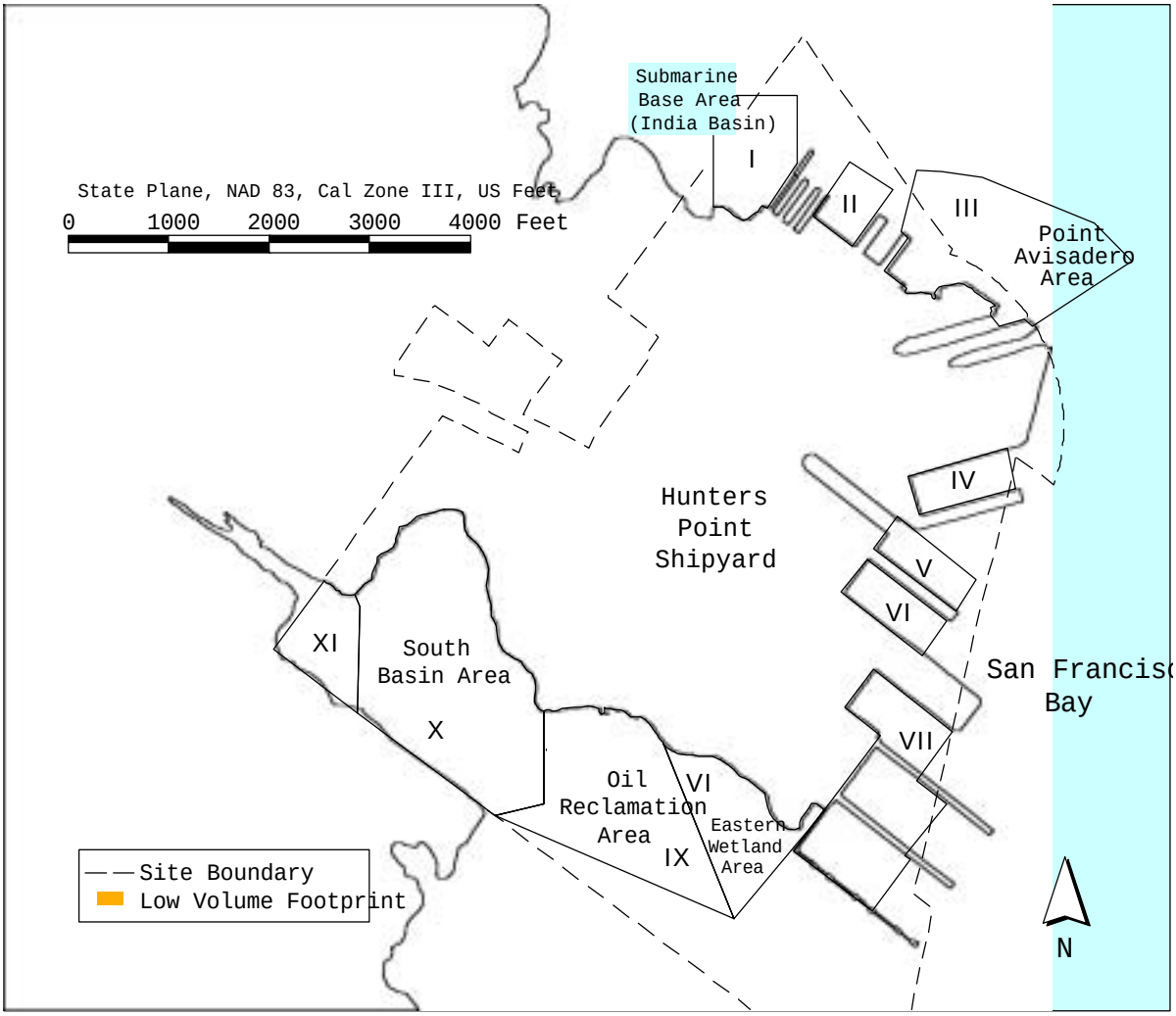

Figure A-1. Hunters Point Sampling Plan for theValidation Study of the 'Low-Volume Footprint'

Appendix B

Hunters Point Sampling Plan for the Validation Study of the 'Low-Volume Footprint'

(from the Hunters Point Validation Study Work Plan, Draft Final; September, 2000)

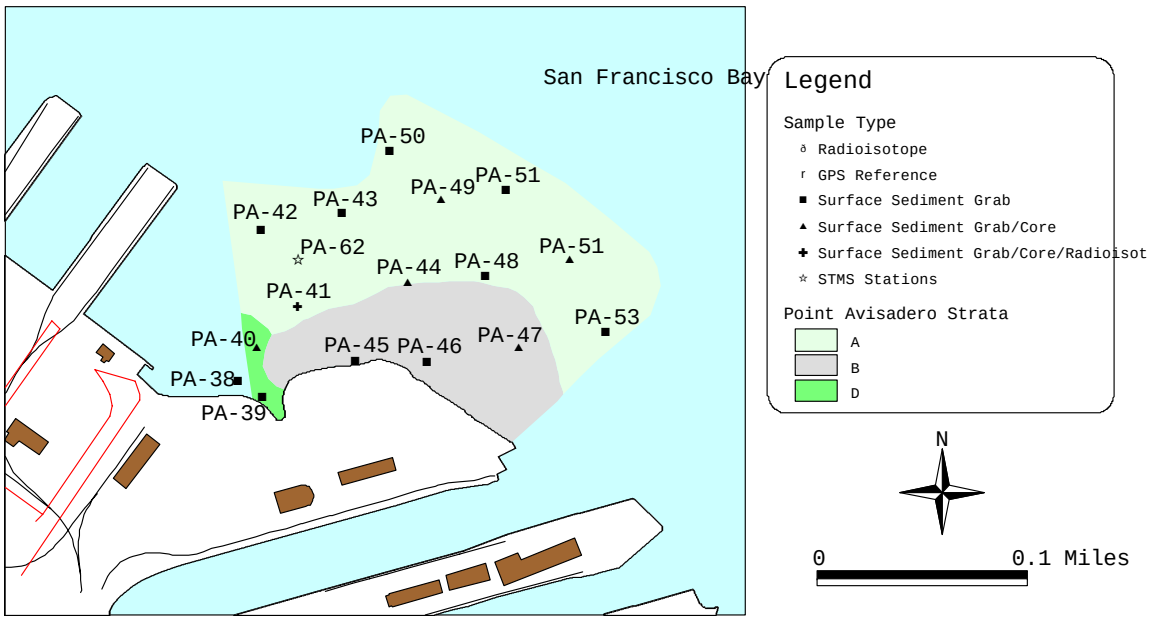

Figure B-1. Sample Locations in Hunters Point Shipyard Area III. (Point Avisadero)

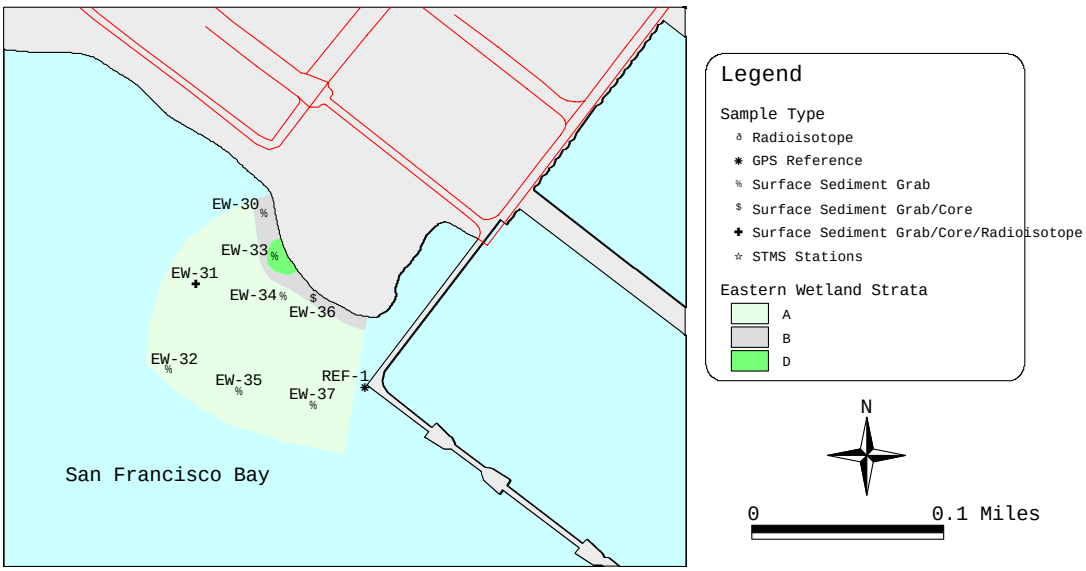

Figure B-2. Sample Locations in Hunters Point Shipyard Area VIII (Eastern Wetland)

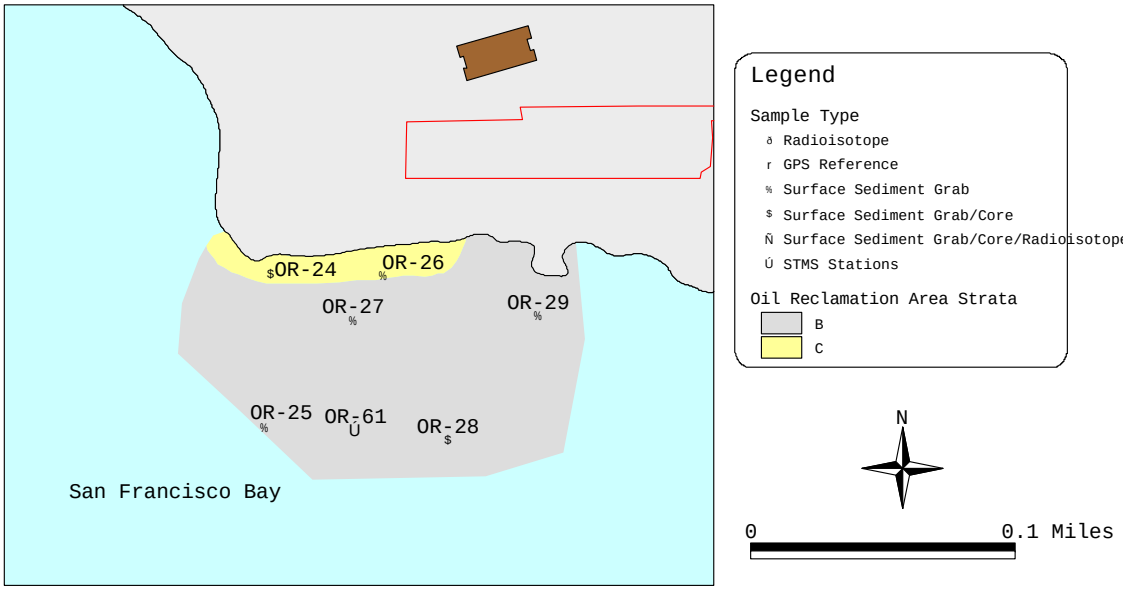

Figure B-3. Sample Locations in Hunters Point Shipyard Area IX (Oil Reclamation Area)

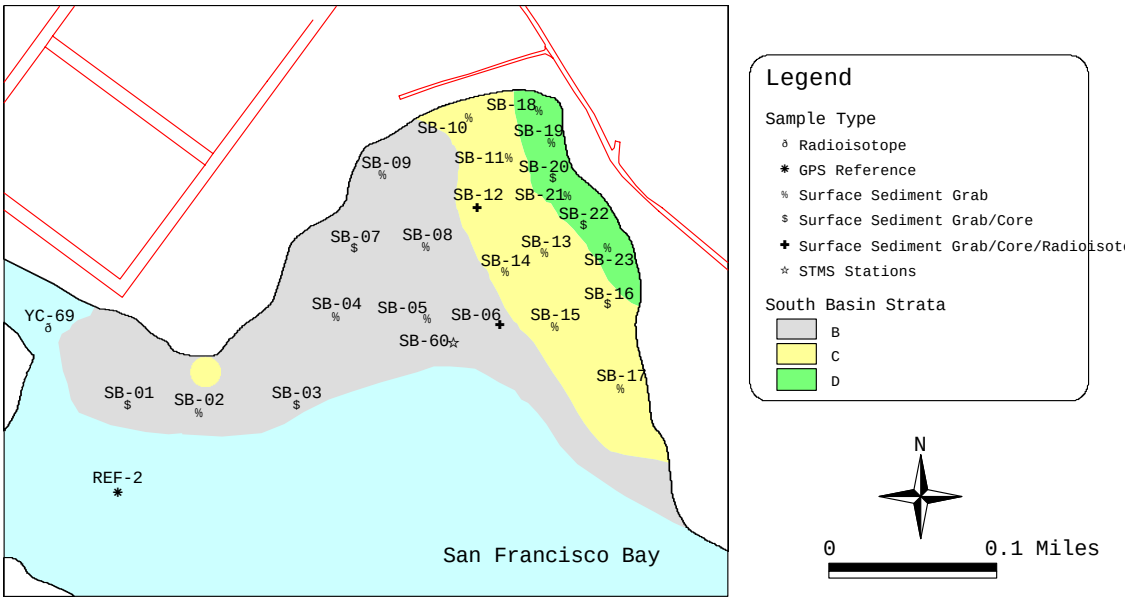

Figure B-4. Sample Locations in Hunters Point Shipyard Area X (South Basin)

ADDENDUM TO THE

WORK PLAN FOR:

CONDUCT OF NAVY SEDIMENT TOXICITY IDENTIFICATION EVALUATION DEMONSTRATION: HUNTERS POINT SHIPYARD (PARCEL F)

SUBMITTED TO:

DEPARTMENT OF THE NAVY
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NAVY BAA Contract
N47408-97-D-0410

Addendum to the Work Plan For:

Conduct Of Navy Sediment Toxicity Identification Evaluation Demonstration: Hunters Point Shipyard (Parcel F)

Revised Sequence for Sediment Pore Water Toxicity Identification Evaluation

The sequential scheme for pore water manipulations will be modified for the Hunters Point TIE in order to minimize uncertainties associated with filtration of the samples. Figure 3-1 has been revised to reflect the new proposed sequence for the TIE. The filtration step has been shifted to occur after the treatments that eliminate toxicity of metals (Na_2 S_2O_3 and EDTA). Following EDTA treatment, the only expected sources of toxicity will be from organics or confounding factors (ammonia and/or sulfides). Because filtration may remove metals and organics, the placement of the filtration step after the treatments for metals reduces ambiguity of interpretations associated with filtration effects. Filtration has not been found to affect confounding factors. Hence, effects that may occur immediately following metals treatments and prior to the C-18 treatment can be expected to be associated with the organic fraction.

Figure 3-1. TIE Fractionation Procedure